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TABLE OF CONTENTS

Short Waves and Long Waves in Transatlantic Radio Telephony
Ralph Bown

The Straight-Line Depreciation Accounting Practice of Telephone Companies in the United States
A. B. Crunden
D. R. Belcher

Installation of New Types of Buried Toll Cable

Long Distance Telephony in Europe
R. W. King

1929 Convertible Bond Offer of the American Telephone and Telegraph Co.
H. Blair-Smith

Listening Device Aids in Combating the Fruit Fly Pest in Florida
D. G. Blattner

Abstracts of Recent Technical Papers from Bell System Sources

Notes on Recent Occurrences

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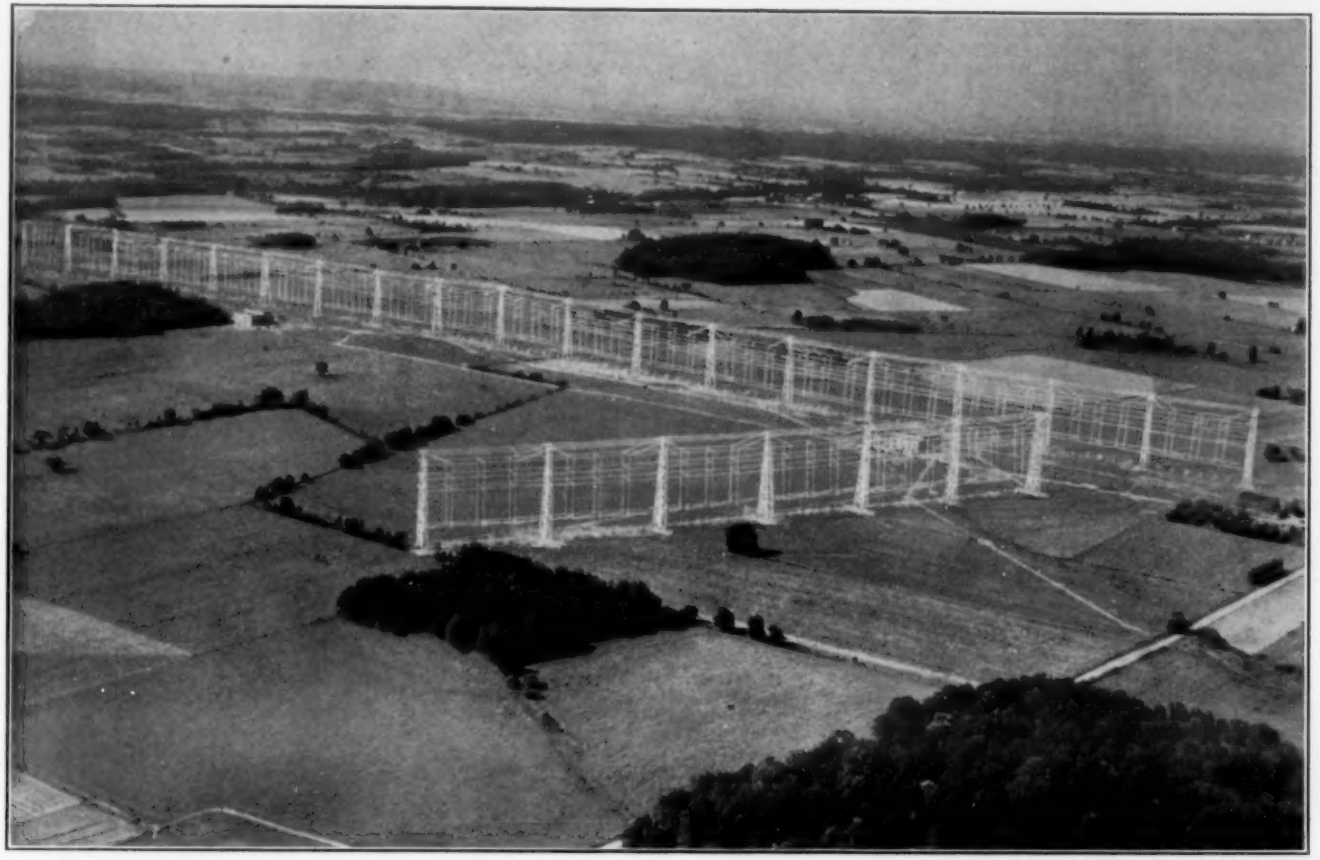

New Short Wave Transmitting Center Near Lawrenceville, N. J. for European and South American Telephone Service
(Airplane photograph retouched to emphasize arrangement of antenna system)

BELL TELEPHONE QUARTERLY

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AND A RECORD OF PROGRESS

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Short Waves and Long Waves in Transatlantic Radio Telephony

THE various points on the two sides of the Atlantic which can now be interconnected by the transatlantic radio telephone system have been added so gradually that the magnitude to which the total network has grown may not be generally appreciated. On January 1, 1929, there were over seven million telephones in Europe and nearly twenty-one million in North America to which transatlantic service was available. The total, twenty-eight million, represents 85 per cent of the telephones in the world. It is inevitable that with such a field to draw from the traffic across the Atlantic should grow vigorously and the need for further telephone links to care for this traffic soon become acute. A telephone cable to provide a circuit of maximum reliability is now being engineered and other radio links are being considered. The type of radio facilities best adapted to meet this need is a problem requiring careful engineering consideration along several lines.

A transatlantic radiotelephone circuit is made up of two one-way radio paths or channels for speech trans-

mission, one transmitting from New York to London and the other transmitting from London to New York. Taken together, these two oppositely directed, one-way channels form a "radio circuit" for two-way speech transmission. At each terminal the incoming and the outgoing radio paths must form a junction with the wire terminal system so as to operate properly with the two-way speech path represented by the single pair of wires extending to the subscriber's telephone instrument. This is done through the agency of an automatic switching device which, in response to the voice current coming from the subscriber's instrument, connects either the incoming or the outgoing radio path to the wire terminal circuit, in accordance with the flow of conversation back and forth, between the two talkers. This junction apparatus or system is the same no matter what type of radio facility is employed in setting up the pairs of channels which link the two junction points. Thus, the choice of radio facilities has been to a large extent divorced from matters of interconnecting these facilities with wire lines.

There are two classes of radio waves capable of traveling long distances and, therefore, suitable for setting up transoceanic radio links. These are: long waves, which may be assumed to include radio frequencies from about 40 kc. to 100 kc. and short waves, which may be assumed to include radio frequencies from about 5,000 kc. to 20,000 kc. The radio frequencies or wave lengths lying between these two classes of waves are suitable for shorter distance transmission and are used for ship-to-shore telegraphy, broadcasting and similar services. The first transatlantic circuit, opened in 1927, was a long-wave circuit. The traffic on it grew to the point where another circuit was needed and, in June, 1928, a short-wave circuit was opened for service. Experience with these two circuits, representing the two wave classes available for the purpose, furnishes a basis for comparative discussion. The first

question which might naturally arise is, which one of these two types of circuit is better adapted to transatlantic radiotelephone service? The answer is, both. The two types have different characteristics. They tend to supplement each other rather than to compete with each other.

There is less difference in the simple transmission efficiency of long and short waves than one might be led to expect by the newspaper reports of long distances often spanned by amateurs using low power short-wave transmitters. A given amount of power radiated toward a distant receiving station under normal conditions produces approximately the same order of received signal strength whether the wave be long or short. There are, however, great differences in the variations in transmission efficiency to which the two classes of waves are subject. Long waves undergo a diurnal variation, signals being stronger at night and weaker by day, but, provided there is reasonably sufficient transmitting power, some signal is always received except for a brief interval at sunset. The workability of the radio link is governed by the amount of noise present to mask or obscure the signal; the way in which this noise varies and the effectiveness of the means used to suppress it govern the results obtained.

A short wave of a given wave length or frequency has good transmission efficiency during only a portion of the day. At other times of the day the efficiency may be so low that substantially no signal can be received. Fortunately, different short-wave lengths have their best transmission at different times of day and it is possible to choose three wave lengths, at least one of which will, under average conditions, be good at any given time. Radio noise is a factor, but one of a lesser order than is the case with long waves. There are two other types of variation which also affect short waves but which are substantially absent with long waves. These are: fading, or relatively rapid,

moment to moment variations in the strength of re-received signals, and "wash out" periods, when, for one or more days transmission may be very poor and signals extremely weak. Wash out periods usually are associated with magnetic storms. During magnetic storms the transmission efficiency of short waves is frequently reduced to the point where communication is impossible until the storm has passed. These three kinds of variations to which short waves are subject are a drawback to their effective use and constitute the transmission problem against which research is now being directed.

One of the prime requirements for telephone service is reliability. Neither the long wave nor the short wave transatlantic circuits give usable results 100 per cent. of the time. With the present apparatus, the long wave circuit is somewhat more reliable than the short wave, but both will be improved as improvements in the apparatus are made and experience is obtained with their operation. Aside from the " sunset dip " poor transmission times on long waves are in general due to excessive noise or static. Poor times on short waves are more often due to weak signals, fading, or magnetic storms. Since the causes in the two cases are different, the likelihood of simultaneous incidence of bad periods on the two wave classes is reduced. This is particularly true, for instance, of the interruptions accompanying magnetic storms, which wipe out short-wave transmission but actually improve long-wave transmission. Thus the combination of a short-wave circuit and a long-wave circuit gives a greater assurance of continuous service than can either type of circuit alone. Whether either type can be brought to a point of reliability sufficient to enable it to furnish continuous service by itself remains for the future to disclose.

Lying, as they do, at opposite ends of the radio frequency spectrum it is not strange that long waves and

short waves employ rather different types of plant. For receiving, both use directive antenna systems to increase signal and decrease noise but these systems are of quite different construction. Long-wave receiving apparatus is similar in many ways to wire carrier telephone equipment. Short-wave receiving apparatus even at its present stage of development involves special devices to combat radio transmission variations and further developments will undoubtedly bring forth many auxiliary devices for this purpose.

For transmitting, long waves require a large and costly antenna to radiate effectively. With present types of antenna, since the radiation goes out in all directions, and only a small part of it travels toward the receiving station, a very powerful transmitter is necessary to produce a sufficient received signal. For short waves, an individual antenna is relatively much smaller and it is possible to combine antennas into arrays which direct the radiation into a small geographical sector. The radiated power is thus used much more effectively and a smaller transmitter will suffice. However, three separate antenna structures must be built to handle the three different wave lengths.

The difference just pointed out between the relatively enormous size of a long-wave antenna and the diminutive size of a single short-wave antenna discloses one reason why experimenters are able to obtain much better long-distance transmission with short than with long waves. A few dollars will buy a short-wave antenna which will compare favorably in simple radiation efficiency with a long-wave antenna costing many thousands of dollars. Thus, an efficient long-wave antenna is denied the average experimenter and we do not hear of long-distance records of transmission being made by experimenters with low-power long-wave sets. When reliable commercial results are required, the expansion of the short-wave antenna into an array and the provision of a number of these arrays to cover the

several wave lengths to be used make the comparison an entirely different sort of thing.

Long-wave systems are more expensive to build and operate than short-wave systems. But considerations of continuity of service must weigh heavily in modifying cost comparisons. Both types of system appear necessary to a well-rounded service.

The preceding remarks apply to transatlantic radio telephone links between United States and England. This route is particularly favorable to the use of long waves since the distance is moderate and the path largely over water, and since the main sources of static are in directions which permit realization of large improvements from directive antennas. For such a route as from United States to South America, where the distance is greater, and where the receiving antennas must look directly toward equatorial regions which are major sources of static, long waves can be of little value and short waves must be relied upon.

RALPH BOWN.

The Straight-Line Depreciation Accounting Practice of Telephone Companies in the United States

(Paper presented to International Congress on Accounting, New York, September 9–14, 1929.)

WHEN the telephone business originated, a little over fifty years ago, electrical science was in its infancy.

There was no accumulated knowledge or experience to which the telephone engineer could have recourse; indeed there was no such person as an electrical engineer as we use the term today. There was no college which taught electrical engineering. There were no electric power lines, no trolley cars.

The telephone was not an improvement upon something previously existing—it was wholly new and strange. When the instruments were made commercially available, the whole science and art of telephony was still to be created. There was no switchboard, no signalling apparatus, no knowledge regarding the telephone line circuit or indeed of any of the facts that have since been found needed to make the telephone a reliably useful thing.

Everything had to be worked out and energetic research and development work brought a continuous flow of inventions. Equipment which had been the best yesterday was today dethroned by something later and better.

In addition to rapid advances in the art affecting all parts of the investment, telephone plants in the open were partially destroyed by storms or other casualties. The great enemy of the outdoor plant proved to be the sleet storm.

The early telephone wire lines in cities, which were almost exclusively aerial, soon became unsightly and

inconvenient and as the size of the plants increased public convenience and necessity were served by the progressive substitution of aerial cables for open wires and later by the introduction of underground conduits and cables which removed many of the lines from sight altogether.

Early Recognition of Depreciation by Telephone Men

Telephone men were thus early brought to a realization that the maintenance cost of providing telephone service included something more than the day-to-day upkeep of the property; it included the cost occasioned by the using up of major portions of the property.

The first circular recommending a system of telephone accounts was sent out by the American Bell Company to its various local licensee companies throughout the country in 1884. Written at a time when depreciation accounting had generally received but scant attention in the business and industrial concerns of America, this circular clearly recognized depreciation as a cost of operation. It said, in part:

> . . . It is certain that the present expense for Repairs and Reconstruction is not proportionate to the actual deterioration of property and that in future years the revenue of most companies will be subjected to much heavier charges on this account. It is suggested that a reserve fund be set apart, to which shall be carried such part of the annual profits as represents the estimated amount of yearly depreciation not covered by the expenditure on account of Repairs and Reconstruction.

A depreciation rate of 10% was suggested in this circular as a reasonable composite rate for all classes of telephone property taken together.

Neglect of depreciation was one of the historical causes of financial disaster to many of the smaller telephone companies in the United States and the ability of the companies of the Bell System and various of the independent companies to maintain themselves is un-

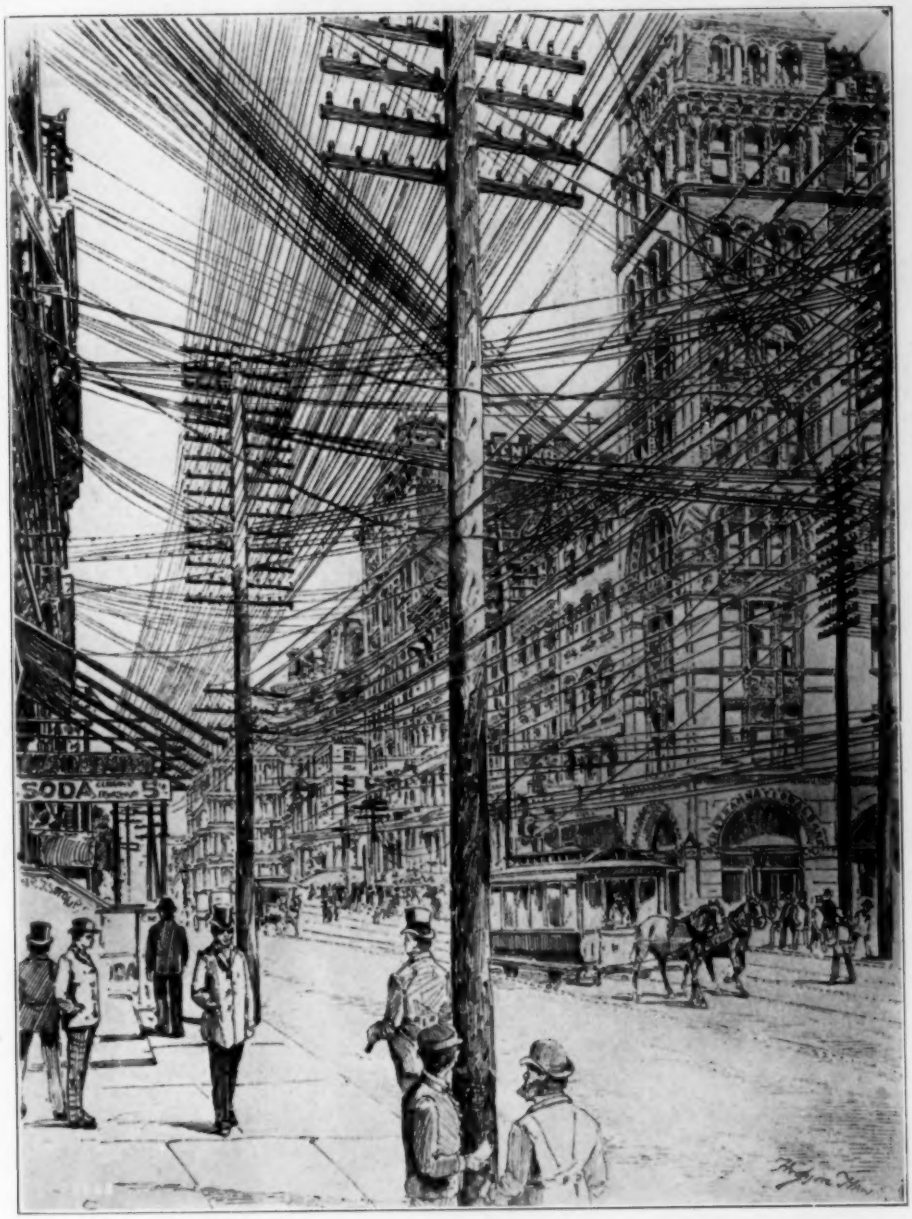


FIG. 1. Broadway and John Street, New York City, 1890

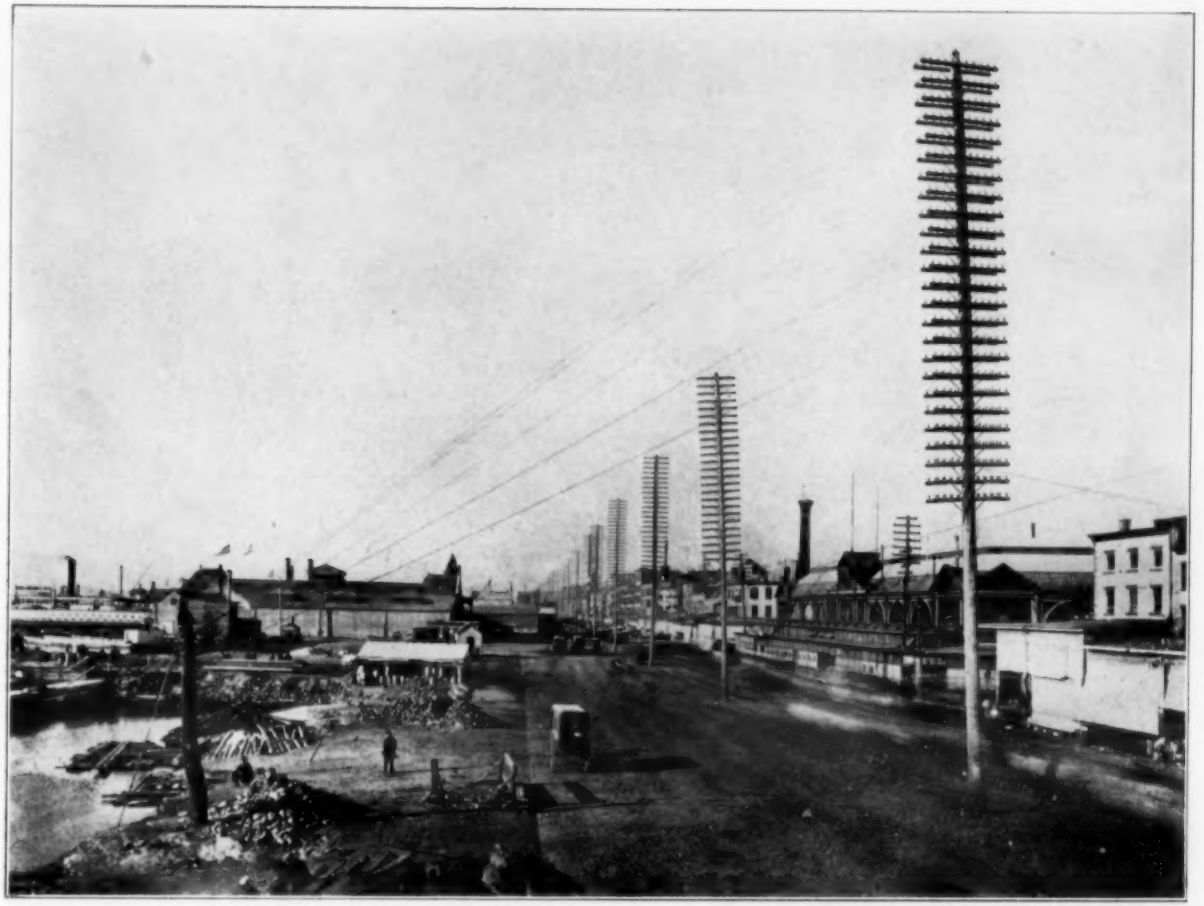


FIG. 2. West Street Pole Line, New York City, Erected in 1887, 90 Foot Poles, 25 Cross-Arms, 250 Wires

doubtedly traceable in part to a better perception of the nature of depreciation in the operating property.

Present Accounting

About the years 1908 to 1910 the Bell Companies generally were making provision for depreciation by charging operating expenses with the difference between (*a*) the amount of depreciation expense computed by the application to the property in use during the year of the current depreciation rates and (*b*) the amount of depreciation overcome by that year's reconstruction. Since that time, the general practice has been to charge operating expense and credit depreciation reserve with the full amount of the accruing depreciation for the year and to charge against the accumulated reserve the losses on property retired; all depreciation transactions being thus mirrored by the reserve.

In 1912, the Interstate Commerce Commission promulgated a Uniform System of Accounts, mandatory for use after December 31st of that year by all of the larger telephone companies throughout the United States. The mandatory system (still in effect) required the use of depreciation reserve accounting and assigned depreciation to the operating expenses as a branch of Maintenance; the annual depreciation charges against earnings to be in such amounts as should distribute, as nearly as may be, evenly throughout the service life of the property, the cost of property consumed in operations. This is accomplished by the "Straight-Line" method.

The formal recognition of depreciation as an operating expense by the government authorities was very satisfactory to the telephone accountants at the time, for in view of the characteristics of the telephone business, they regarded—as indeed they still do—a sound method of depreciation accounting as imperative for it.

The universal agreement on this point among both

Bell and independent telephone companies and the government experts is significant.

Characteristics of Depreciable Telephone Property

Some of the characteristics of the telephone business of importance in this relation are:

Growth

The business has increased in a half century amazingly. Beginning with a few hundred thousand dollars

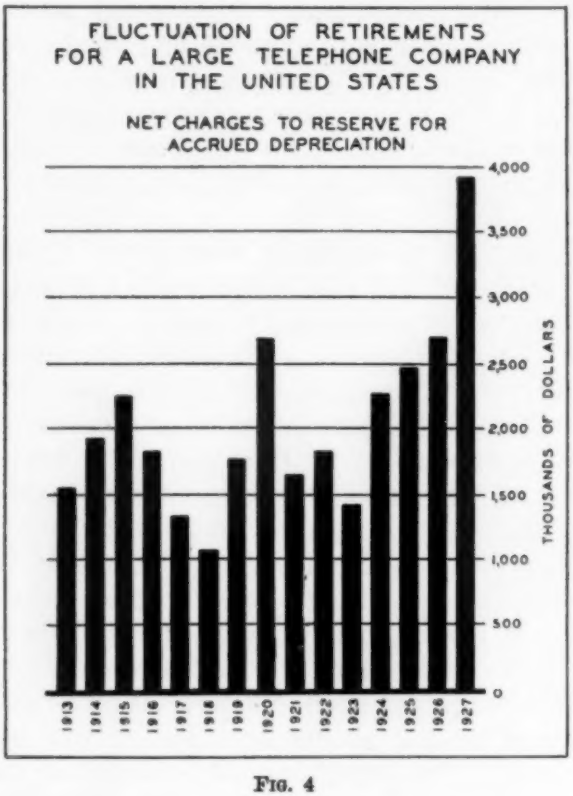


Fig. 4

in 1878, the Bell Companies had in 1917 plants which had a first cost of over one billion dollars. From 1917 to 1923 another billion dollars was added, as net prop-

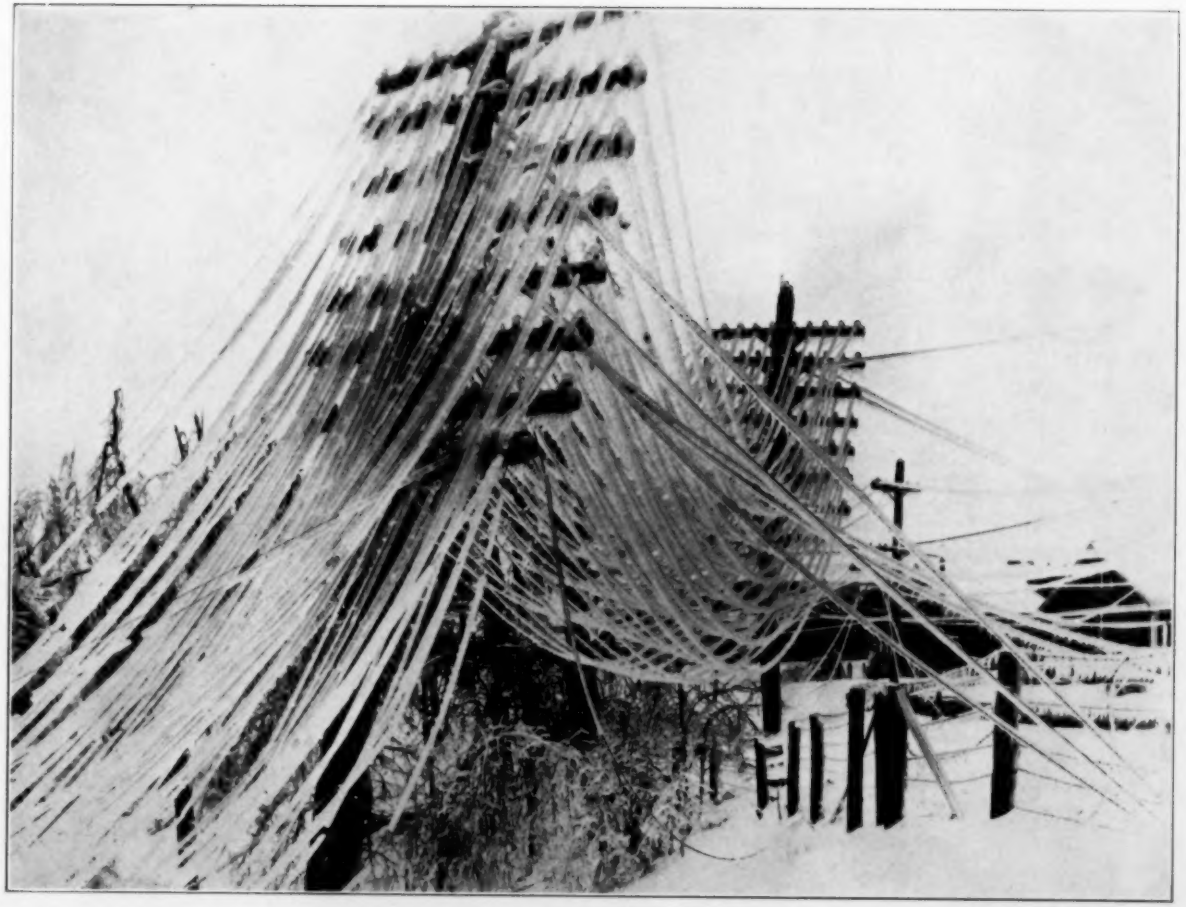


FIG. 3. Result of Sleet Storm

erty additions. At present these companies have more than three and a quarter billions of dollars of telephone property and the four billion mark will be passed shortly after the close of this decade. The telephone companies not comprised in the Bell System also have very considerable growing property investments.

Short Service Life

Due to wear and tear, changes in the art, storms and casualties, public requirements and above all to inadequacy due to growth of the service, most telephone plant has a relatively short service life; the average composite life of the plant as a whole, excluding underground conduit, being less than fifteen years.

Fluctuation in Retirements

Retirements are by no means uniform from year to year. They fluctuate over a wide range, not merely for the individual classes of plant, but for all of the classes taken together. The annual fluctuations are so serious that if the net retirement charges for the year were taken into the operating expenses in lieu of the proper depreciation accrual, these expenses—in addition to seriously understating the true expense of depreciation —would be highly irregular.

Location of Property

A large percentage of telephone property is placed upon premises not under the control of the telephone company, such as public buildings, highways and alleys and the premises of its individual subscribers. This property is subject to the changing conditions affecting such public or private property, as well as to ordinary depreciation hazards.

With these special characteristics of the telephone business in view, the suitability of the straight-line method will be apparent probably to most accountants. But not everyone is an accountant and it has frequently

been necessary to explain and to defend the fundamental soundness of the depreciation rules of telephone companies.

The Theory of "Straight-Line" Telephone Depreciation

The Bell System's position in respect of straight-line depreciation accounting admits of very simple statement.

The operating expenses to be entire must reflect the cost of all of the things purchased and used up in conducting the operations. This includes the cost of some things which are used up at once or in a short time, such as operating labor, lunch room supplies, coal or stationery; and of other things which are used up slowly, such as tools, furniture, automobiles, poles and switchboards. The ultimate cost of a service must include the cost of everything used up in furnishing it, and if a telephone company in the rendition of its telephone service uses up any property, then the cost of that property is necessarily a part of the cost of that service.

The function of the accounts is to record the facts as to the transactions of the company. Any item of operating cost is an operating expense. If any item of such cost is omitted from the operating expenses they will not reflect the facts. Granting that the cost of property used up is operating expense, the next question which presents itself is as to the time when the expense should be charged in the accounts. It is a fundamental rule of accounting that charges for expense should be made to the accounts of the period to which the expense relates and for the benefit of which it has been incurred. The expense of depreciation is incurred within the period when the property is being employed to render the service. It should therefore be charged to operating expenses within that period.

In the case of depreciable property of long life, the books must be opened and closed many times during the

life term and so the further problem arises as to how the accounts of each period can be made to provide equitably for the cost of the property which is being consumed. The straight-line method meets this problem simply, effectively and equitably. The company charges off against its revenues the actual net capital loss and only that loss, as nearly as it may be determined, and it charges to the operating expenses of any period only that proportion of the loss which is measured by the length of that period as related to the length of the entire useful life of the property lost. This practice is equitable because it reflects expense in the operating costs of successive accounting periods, only for such depreciable property as is in use for the benefit of these periods, and in an amount which is uniform and fair for each period, taken either separately or in combination with others.

There is nothing anomalous in the way this item of expense is treated under such a plan. It is the general practice to accrue within a term any expense incurred for that term regardless of when the cost is paid, whether in advance or in arrears. Taxes are accrued during the period to which the tax relates. Insurance premiums are apportioned to accounts over the life term of the policy. The same rule is followed with bond discounts and many other items. However, we should not insist that time is the sole unit of measurement applicable to the straight-line method. It has proven, so far, a quite suitable unit for employment in the telephone business, where the production and use of the service are continuous and variation in the extent of operating use causes as a rule but slight variation in the rate of wear and tear of the equipment. It is easy to conceive of cases in which the extent of use of depreciable property oscillates, or even fluctuates, widely in successive periods, and there are many industries where wear and tear is a major factor in depreciation closely associated with a varying extent of use.

The straight-line method is sufficiently versatile to

permit the employment of time in active operation, volume of output and similar units of measurement.

It is, of course, evident from what has just been said that the Bell System depreciation reserve is a retirement reserve, not a replacement reserve. Under the theory as stated, the amount of replacements cannot affect the amount of this depreciation expense. It is what the company loses in the way of original capital consumed which determines the amount of the loss, which would be exactly the same regardless of whether or not replacements are made. Telephone companies moreover seldom make replacements in kind, some other or different equipment or construction being usually necessary. It would be impossible to estimate years ahead what replacement costs are going to be, and in any event, it is fairly certain that investors in telephone securities are not primarily interested in property as such but are interested in safeguarding the money invested in the property which so far as it will some day be lost in operations, is therefore what should be covered by the depreciation provision.

Relation of Current Maintenance to Depreciation

We define depreciation for accounting purposes as the expense occasioned by the using up of physical property employed as fixed capital. This results in a complementary definition of current maintenance as the expense occasioned by keeping such physical property in condition necessary for continued use during its service life. These definitions seem to have the simplicity and clearness characteristic of good definitions. Of course, in practice some minor concession has to be made to economy and convenience. It is the aim of the accountants of the Bell System, as it is of accountants generally, to produce results as correct as possible with reasonable limitation of expenditure for accounts and records.

Units of Property

On this account it is the practice in specifying the items of property to be given depreciation treatment to exclude minor and inconsequential items which can be safely accounted for as part of or auxiliary to the items which are specified. For example: In the aerial cable plant, the main expenditure is for the aerial cable itself, while a minor part of the total cost is made up of suspension strand wire, clamps, rings and other hardware. The unit of property selected for depreciation purposes is: "One span of aerial cable"—one span being the length of cable suspended between two poles. If one or more spans of cable are retired, the cost of property lost is charged to the depreciation reserve and this charge covers the associated suspension strand, clamps, rings, etc. But if any amount of strand, clamps or rings is renewed to keep the composite cable structure in good working condition during the service life of the aerial cable which is the principal constituent of the structure, the charge is to current maintenance. It is not the custom to allow suspension strand and rings to remain standing in the plant after the retirement of the aerial cable which they were erected to support, but in the unlikely event that such items should so stand for a considerable time and be eventually retired by themselves, no retirement entry would be necessary for them, because the proper amount of such auxiliary items is included in the average retirement unit cost for the aerial cable.

Average Unit Costs

Generally speaking, the retirement unit costs used in the Bell System are averages of original cost per unit, so calculated and recalculated currently that if, for example, all the units in the cable account with their associated elements were to be instantaneously retired from service, the accounting procedure would then and there empty the asset account for cable, leaving it at zero. This plan gives assurance, on the basis of aver-

ages, that no physical property costs remain in the asset accounts after the physical property itself has in fact gone out of service.

Property Individualized

In the case of buildings, large switchboards and machines and certain other items which can be conveniently individualized for accounting purposes, actual original cost is maintained and it is not necessary to resort to the use of average costs.

Ascertainment of Service Lives on the "Group" Basis

A very important consideration in modern depreciation accounting is the problem of group treatment.

Our good accounting books tell us that the factors which enter into straight-line accounting for depreciation are, first, the cost of the property; second, the net salvage or junk value realizable upon the retirement of the property and third, the life in service, represented by the number of accounting periods within which the service life of the property is comprised. The proportion of expense chargeable to any single period is the consumable portion of original cost (total cost, less salvage) divided by the number of periods involved.

The amount of depreciation chargeable annually on this basis divided by the original cost of the depreciable property is the annual depreciation rate.

This is fairly simple, but a complex situation arises in actual practice because in large modern undertakings the items become so exceedingly numerous. For example, one of the large companies of the Bell System has over 721,020 poles, 12,000,000 conductor miles of wire and over 2,000,000 sets of subscribers' instruments.

It is impossible to deal with the individual service life of each item, such as a pole or a telephone instrument. It is necessary to study the behavior of large groups of such items.

THE "GROUP" BASIS

PRO FORMA CALCULATION OF GROUP DEPRECIATION RATE AND RESULTING ACCOUNTING TREATMENT

UNITS	SERVICE YEARS	UNIT YEARS
5	.5	2.5
7	1.5	10.5
8	2.5	20.0
10	3.5	35.0
15	4.5	67.5
35	5.5	192.5
60	6.5	390.0
90	7.5	675.0
120	8.5	1,020.0
150	9.5	1,425.0
150	10.5	1,575.0
120	11.5	1,380.0
90	12.5	1,125.0
60	13.5	810.0
35	14.5	507.5
15	15.5	232.5
10	16.5	165.0
8	17.5	140.0
7	18.5	129.5
5	19.5	97.5
1,000	X	10,000.0
10,000 ÷ 1,000 = 10 YEARS		

YEAR	INVESTMENT AT BEGINNING OF YEAR (a)	RETIREMENTS DURING YEAR (b)	AVERAGE INVESTMENT DURING YEAR (c)	ANALYSIS OF ENTRIES PASSING THROUGH "DEPRECIATION RESERVE" ACCOUNT — ENTRIES: * CREDITS (d)	ENTRIES: DEBITS (e)	BALANCE: ANNUAL NET CREDITS (f)	BALANCE: ANNUAL NET DEBITS (g)	BALANCE: CUMULATIVE NET CREDIT (h)
1	$1,000	$ 5.00	$997.50	$ 99.75	$ 5.00	$94.75	$	$ 94.75
2	995	7.00	991.50	99.15	7.00	92.15		186.90
3	988	8.00	984.00	98.40	8.00	90.40		277.30
4	980	10.00	975.00	97.50	10.00	87.50		364.80
5	970	15.00	962.50	96.25	15.00	81.25		446.05
6	955	35.00	937.50	93.75	35.00	58.75		504.80
7	920	60.00	890.00	89.00	60.00	29.00		533.80
8	860	90.00	815.00	81.50	90.00		8.50	525.30
9	770	120.00	710.00	71.00	120.00		49.00	476.30
10	650	150.00	575.00	57.50	150.00		92.50	383.80
11	500	150.00	425.00	42.50	150.00		107.50	276.30
12	350	120.00	290.00	29.00	120.00		91.00	185.30
13	230	90.00	165.00	16.50	90.00		71.50	113.80
14	140	60.00	110.00	11.00	60.00		49.00	64.80
15	80	35.00	62.50	6.25	35.00		28.75	36.05
16	45	15.00	37.50	3.75	15.00		11.25	24.80
17	30	10.00	25.00	2.50	10.00		7.50	17.30
18	20	8.00	16.00	1.60	8.00		6.40	10.90
19	12	7.00	8.50	.85	7.00		6.15	4.75
20	5	5.00	2.50	.25	5.00		4.75	
21								
TOTAL		$1,000.00		$1,000.00	$1,000.00			

*CONTRA OF CHARGES TO EXPENSE ACCOUNT "DEPRECIATION"

FIG. 5

The first step obviously is to make such division of the asset accounts into certain groups as will insure reasonable homogeneity in the groups. The Uniform System of Accounts does this. Pole Lines are in one account, Aerial Cables in another, Open Wire in another. Subscribers' station apparatus, private branch exchanges and telephone booths are each in a separate account.

Let us consider the pole line account. As soon as we propose an accounting on the basis of groups of poles, we are faced with the fact that of the poles going into the plant in any one year, some will have a much longer life than others. Some poles will be retired because of storms, others because of public convenience, others because of the substitution of underground for overhead distribution. There will be a wide dispersion of retirements.

We have also to consider that as soon as a pole is physically retired its cost must be removed from the fixed capital account and so the depreciation rate must be applied to a changing quantity of poles. As to the group of poles installed in any one year, it will be applied always to the remainder, continually growing less, of the original number of poles. The whole of the book account for poles will cover the remainders of many such groups of poles, one group for each year of original installation.

Analogy to Life Insurance

The problem of determining average service lives for telephone plant where there is a substantial variation in age at retirement is similar to that of the life insurance actuary in determining the expectation of human life. The recorded experience upon which the studies of the life insurance actuary are based, covers large numbers of men. It shows, first, out of the total number of individuals constituting the group under observation how many were alive in each year of age

and therefore "exposed to the risk of dying," to use an actuarial expression, during that year, and second, how many actually did die during each year of age. Based upon this information the life insurance actuary is able to compute rates of human mortality by age and from

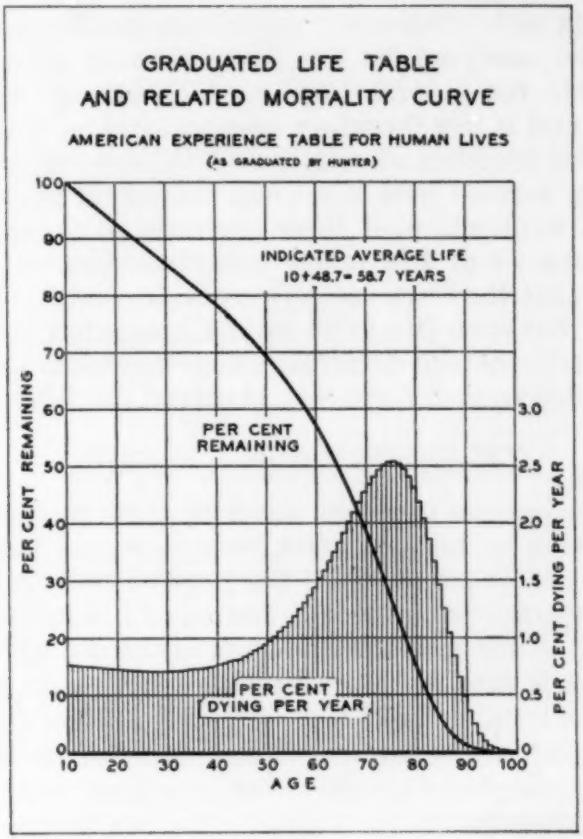


FIG. 6

these to determine the related expectation of life. This latter determination is based upon the calculation of a "Life Table" consisting of a series of figures which show for an initial group of individuals at a given age the number who will survive for each successive year of age thereafter.

The ratio between the number dying in any one year and the number exposed to the risk of dying, constitutes "the mortality rate" for that year of age. There is a well developed actuarial procedure by which a series of such mortality rates by age can be converted into a life expectancy for the group.

Data as to retirement experience similar to the experience analyzed by the life insurance actuary are available for several important classes of telephone plant, and it has therefore been natural to apply such actuarial methods of analysis in the determination of average service lives for those classes of plant. Extended application of those methods to thousands of telephone plant life tables has demonstrated conclusively that they are entirely suitable, and it has been found that each life table can be adequately described by a mathematical formula, whose constants are separately determined from each observed life table.

Gompertz-Makeham Formula

The formula involved was first given mathematical expression by two actuaries, Gompertz and Makeham, and is widely employed at the present time by life insurance actuaries in the graduation of life tables.

One of the interesting points about the use of this formula is that in spite of its complexity, its application has been reduced to a series of routine computations which can be carried out to completion by ordinary skilled comptometer operators, working under competent supervision.

As might be anticipated, the mortality rates for any given age are by no means identical for all classes of telephone property. Indeed, they are not the same for a single class of such property for various sections of the country, and even in a particular part of the country there may be a change in the rate as the environment of the plant undergoes a change. The flexibility of the Gompertz-Makeham formula is such, however,

PRINCIPAL MATHEMATICAL FORMULAS

USED IN GRADUATION OF LIFE TABLES DEVELOPED FROM "FINAL SUMMARY OF HISTORICAL DATA FOR MORTALITY STUDY"

(1) $l_x = k\, s^x g^{c^x}$ (GOMPERTZ-MAKEHAM FORMULA)

(2) $$\frac{t c^{t+\frac{1}{2}} - \frac{c^{t+\frac{1}{2}} - c^{\frac{1}{2}}}{c-1} c - (c-1)\left[\frac{t^2-t}{2} + \frac{4t^3-3t^2-t}{12} C_e\right]}{c^{t+\frac{1}{2}} - c^{\frac{1}{2}} - (c-1)\left[t + \frac{t^2}{2} C_e\right]} = \frac{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - \frac{t^2-t}{2} L_0 - \frac{4t^3-3t^2-t}{12} A}{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - t L_0 - \frac{t^2}{2} A}$$

(3) $$\log g = \frac{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - t L_0 - \frac{t^2}{2} A}{c^{t+\frac{1}{2}} - c^{\frac{1}{2}} - (c-1)\left[t + \frac{t^2}{2} C_e\right]} (c-1)$$

(4) $$\log g = \frac{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - \frac{t^2-t}{2} L_0 - \frac{4t^3-3t^2-t}{12} A}{t c^{t+\frac{1}{2}} - \frac{c^{t+\frac{1}{2}} - c^{\frac{1}{2}}}{c-1} c - (c-1)\left[\frac{t^2-t}{2} + \frac{4t^3-3t^2-t}{12} C_e\right]} (c-1)$$

(5) $\log s = A - C_e \log g$

---

(6) $l_x = k\, s^x r^{x^2} g^{c^x}$ (EXTENDED GOMPERTZ-MAKEHAM FORMULA)

(7) $$\frac{t c^{t+\frac{1}{2}} - \frac{c^{t+\frac{1}{2}} - c^{\frac{1}{2}}}{c-1} c - (c-1)\left[\frac{t^2-t}{2} + \frac{4t^3-3t^2-t}{12} C_e + \frac{t^2-t}{48}(6t^2+t-1) C_e^2\right]}{c^{t+\frac{1}{2}} - c^{\frac{1}{2}} - (c-1)\left[t + \frac{t^2}{2} C_e + \frac{4t^3-t}{24} C_e^2\right]}$$
$$= \frac{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - \frac{t^2-t}{2} L_0 - \frac{4t^3-3t^2-t}{12} A - \frac{t^2-t}{48}(6t^2+t-1) B}{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - t L_0 - \frac{t^2}{2} A - \frac{4t^3-t}{24} B}$$

(8) $$\log g = \frac{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - t L_0 - \frac{t^2}{2} A - \frac{4t^3-t}{24} B}{c^{t+\frac{1}{2}} - c^{\frac{1}{2}} - (c-1)\left[t + \frac{t^2}{2} C_e + \frac{4t^3-t}{24} C_e^2\right]} (c-1)$$

(9) $$\log g = \frac{\sum_0^{t-1} {}^2\!\Delta_{x+\frac{1}{2}} - \frac{t^2-t}{2} L_0 - \frac{4t^3-3t^2-t}{12} A - \frac{t^2-t}{48}(6t^2+3t-1) B}{t c^{t+\frac{1}{2}} - \frac{c^{t+\frac{1}{2}} - c^{\frac{1}{2}}}{c-1} c - (c-1)\left[\frac{t^2-t}{2} + \frac{4t^3-3t^2-t}{12} C_e + \frac{t^2-t}{48}(6t^2+t-1) C_e^2\right]} (c-1)$$

(10) $\log s = A - C_e \log g$

(11) $\log r = \frac{1}{2}\left[B - C_e^2 \log g\right]$

NOTE: $A = \left[\frac{d L_x}{dx}\right]_{x=0}$

$B = \left[\frac{d^2 L_x}{dx^2}\right]_{x=0}$

OTHER CAPITAL LETTERS REPRESENT LOGARITHMS OF CORRESPONDING SMALL LETTERS.

FIG. 7

that no difficulty is introduced by these facts. A set of constants can be determined from the recorded observations, from which some one curve out of the infinite number of conceivable Gompertz-Makeham curves can be derived as representative of the mortality experience

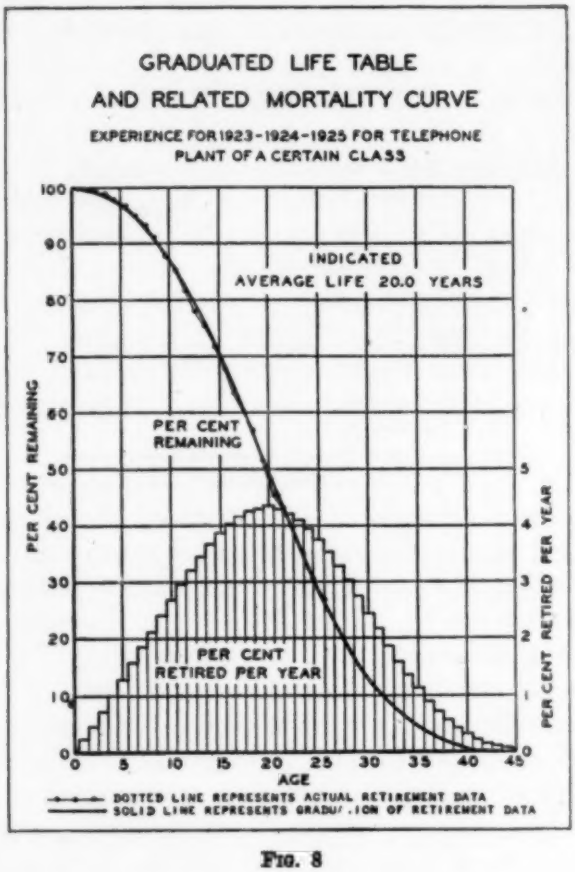

GRADUATED LIFE TABLE
AND RELATED MORTALITY CURVE
EXPERIENCE FOR 1923-1924-1925 FOR TELEPHONE PLANT OF A CERTAIN CLASS
INDICATED AVERAGE LIFE 20.0 YEARS
PER CENT REMAINING
PER CENT RETIRED PER YEAR
PER CENT REMAINING
PER CENT RETIRED PER YEAR
AGE
DOTTED LINE REPRESENTS ACTUAL RETIREMENT DATA
SOLID LINE REPRESENTS GRADU..ION OF RETIREMENT DATA

Fig. 8

of property, of the class and in the situation under examination, and wherever the life history is not yet complete, this curve will provide a logical and scientific basis for projection of an observed life table out to its close.

One of the advantages of the actuarial method of

studying plant mortality is ability to bring the depreciation studies closely up-to-date.

"Band" Analysis

Owing to improvements in the telephone art, telephone companies are today obtaining a longer average life from many plant elements than was formerly the case. For this reason a study of the retirement experience in recent years is of especial significance and it is the practice to make concentrated study of portions of recorded experience, confined to a given strip or band of the tabular matter. Taking the band of say 1928 as an illustration: This would disclose the first years' retirements on plant installed one year ago, the second year's retirements on plant installed two years ago, the third year's retirements on plant installed three years ago, and so on backward, say to the thirtieth and final years' retirements on plant installed thirty years ago and now completely retired.

The band study substitutes for the complete analysis of say, 30 years' experience of one group, an analysis of one year's experience with say 30 groups, each group successively one year later in time of installation than its next predecessor group. One study scans, as it were, the warp while the other scans the woof, of the statistical fabric.

The advantages gained are first, the greater reliability of the most recent records, and second, the reflection in the results of the most recent company policy and plant administrative technique.

The two sorts of studies mentioned may be made in conjunction, the results compared and their mutual consistency derived. In practice, studies are not ordinarily made of bands for a period so short as one year. Three years is generally as narrow a band as the quantity of data will justify as adequate. The bands may be selected so as to overlap; for example having analyzed the 1915–17 band, the next band taken may be 1916–18, then 1917–19 and so on.

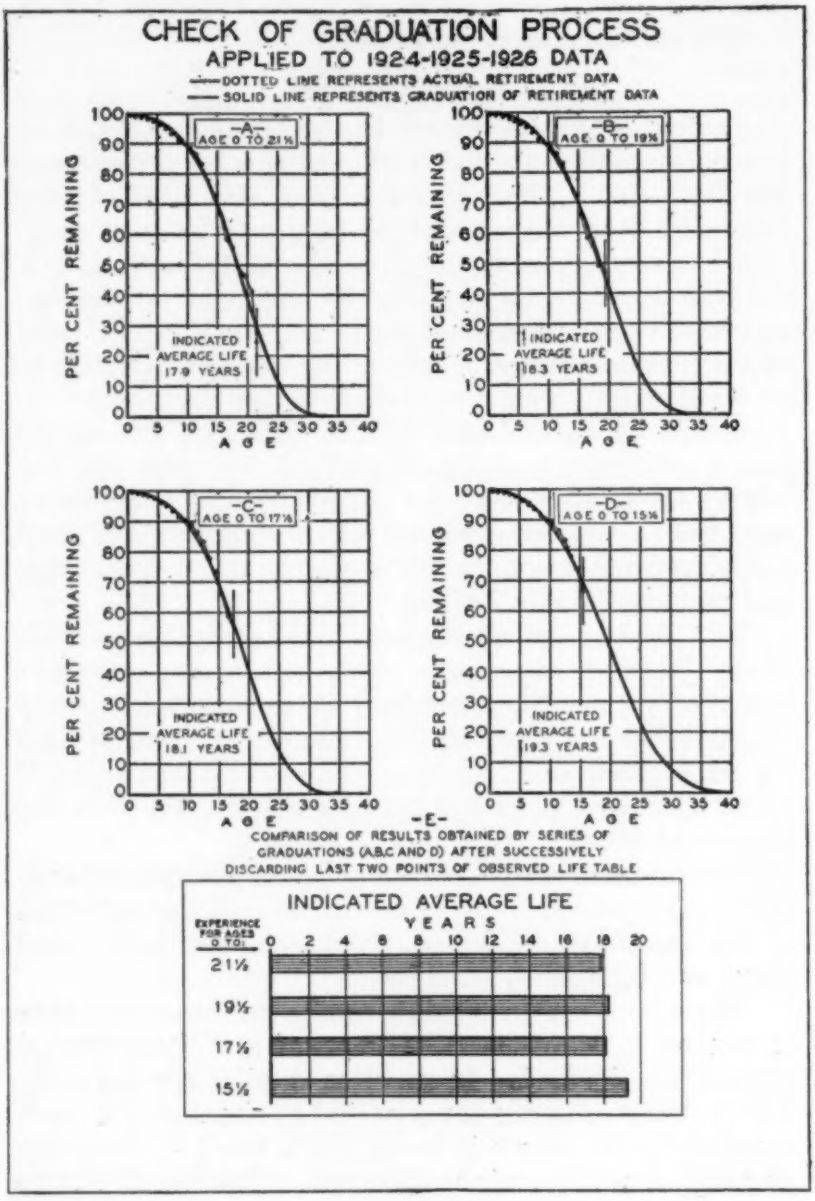

CHECK OF GRADUATION PROCESS
APPLIED TO 1924-1925-1926 DATA
DOTTED LINE REPRESENTS ACTUAL RETIREMENT DATA
SOLID LINE REPRESENTS GRADUATION OF RETIREMENT DATA
-A-
AGE 0 TO 21½
INDICATED AVERAGE LIFE 17.9 YEARS
-B-
AGE 0 TO 19½
INDICATED AVERAGE LIFE 18.3 YEARS
-C-
AGE 0 TO 17½
INDICATED AVERAGE LIFE 18.1 YEARS
-D-
AGE 0 TO 15½
INDICATED AVERAGE LIFE 19.3 YEARS
PER CENT REMAINING
AGE
-E-
COMPARISON OF RESULTS OBTAINED BY SERIES OF GRADUATIONS (A,B,C AND D) AFTER SUCCESSIVELY DISCARDING LAST TWO POINTS OF OBSERVED LIFE TABLE
INDICATED AVERAGE LIFE
YEARS
EXPERIENCE FOR AGES 0 TO
21½
19½
17½
15½

FIG. 9

Turn-over Method

For certain classes of telephone property, the actuarial method just described cannot be employed in practice on account of technical difficulties and expense in the collection of data.

For these classes, an alternative method of procedure is employed, which has been denominated the "turn-over method." Those familiar with life insurance will understand at once the fundamental principle of the turn-over plan when we say that it is the same as that which is involved in the relation of total deaths of human beings of all ages to exposed population of all ages in a non-growing community.

The accounts of the telephone companies are kept to show separately the amount of plant of each class going new into the plant in any year and the amount of old plant of each class retired from service in any year.

If the class of plant were to remain stationary in amount and stable in its life characteristics and age distribution, the average time that plant remained in service could be readily ascertained from a relation of either the retirements or the replacements to the total plant. Either the length of the period of time required for the most recent replacements to accumulate to the amount of the plant at the end of that period or the length of the period of time required for the retirements to accumulate backwards in time to the amount of the plant at the beginning of that period—the two periods being the same—would be the length of the life of plant of the given class, on the average.

Determination of the average life of telephone property on this basis is made difficult by several conditions; viz.:

a Changes in the life characteristics of plant which occur during the period studied.

b Changes in the purchasing power of the dollars, in which the books are kept, whereby a given number of dollars may represent more or less plant than formerly.

EXAMPLE TO ILLUSTRATE PRINCIPLE OF TURNOVER METHOD

PLANT GROWING AT THE RATE OF 10% ANNUALLY
DATA IN TERMS OF PLANT COSTS — AVERAGE LIFE OF UNITS 10 YEARS

TABLE OF PLANT UNITS AND COSTS

YEAR	PLANT PLACED			PLANT RETIRED				PLANT IN SERVICE JANUARY 1st	
	NUMBER OF UNITS 1	UNIT COSTS 2	TOTAL COST 3	NUMBER OF UNITS 4	UNIT COSTS 5	TOTAL COST 6	TOTAL COST ACCUMULATED FROM 1926 7	NUMBER OF UNITS 8	TOTAL COST 9
1913	50,545	$1.00	$50,545	20,826	$1.00	$20,826		292,982	$292,982
1914	55,599	.90	50,039	23,110	1.00	23,110		322,701	322,701
1915	61,159	1.10	67,275	25,539	1.00	25,539		355,190	349,630
1916	67,275	1.60	107,640	28,183	1.00	28,183		390,810	391,366
1917	74,003	1.80	133,205	31,010	1.00	31,010		429,922	470,843
1918	81,403	1.65	134,315	34,112	1.00	34,112	$ 602,491	472,915	573,038
1919	89,543	1.40	125,360	37,523	1.00	37,523	568,379	520,206	673,241
1920	98,497	1.60	157,595	41,273	1.33	54,893	530,856	572,226	761,078
1921	108,347	1.30	140,851	45,404	1.37	62,203	475,963	629,450	863,780
1922	119,182	1.25	148,978	49,942	1.36	67,921	413,760	692,393	942,428
1923	131,100	1.35	176,985	54,935	1.34	73,613	345,839	761,633	1,023,485
1924	144,210	1.40	201,894	60,429	1.35	81,579	272,226	837,798	1,126,857
1925	158,631	1.55	245,878	66,475	1.35	89,741	190,647	921,579	1,247,172
1926	174,494	1.50	261,741	73,120	1.38	100,908	100,908	1,013,735	1,403,309
1927	-	-	-	-	-	-	-	1,115,109	1,564,144

APPLICATION OF TURNOVER METHOD

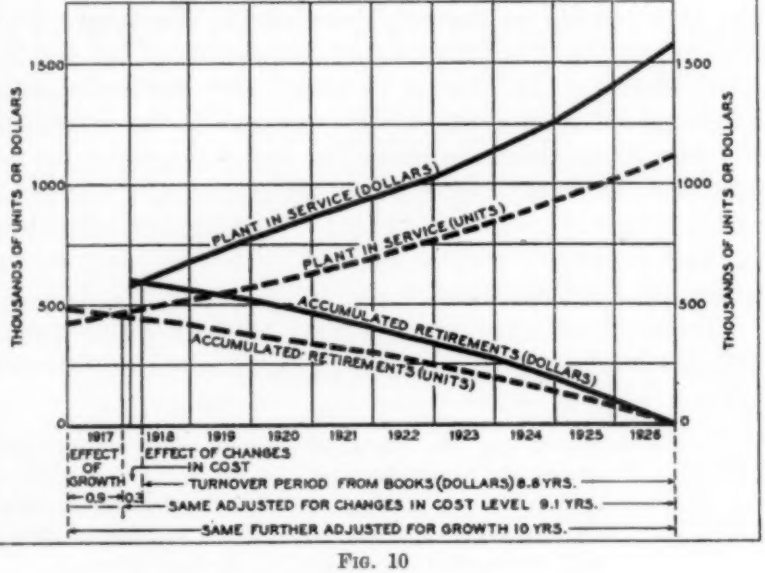


FIG. 10

c Growth, positive or inverse, in the total plant of the given class during and preceding the period studied, which disturbs the mortality ratio. When retirements are studied, for example, positive growth introduces the condition that some of low age mortalities of the added plant which produces the growth enter the results as a disturbing element.

d Purchases and sales of telephone plant from one company to another. These transactions operate like sudden growth.

None of these difficulties is insuperable. The changes in the characteristics of plant may be fairly well recognized. The changes in the value of money can be compensated by placing the study upon an "index number" basis. Suitable methods have been developed to make allowance for the effect upon the turn-over period of such growth as may have taken place.

The turn-over method while theoretically inferior to the actuarial method has been found practically very useful and dependable.

Special Cases—Buildings and Central Office Equipment

For two classes of telephone property, buildings and central office telephone equipment, we find that the best way to estimate the depreciation rates is to forecast how long, in view of population growth and the progress of the service, existing buildings and equipment will individually serve to meet the needs of the community.

The long-term basis upon which plant of these classes is engineered is such that forecasts of this sort can be made with a reasonable approach to accuracy and in the case of central office telephone equipment, the existence of a condition peculiar to such equipment should be mentioned.

Central Office telephone equipment is usually not installed to the full capacity of the Central Office at the time of initial provision of such equipment. A certain

quantity of equipment is installed sufficient to provide service for a given number of years and is added to from time to time as demand increases, the later equipment being commingled with the earlier.

We thus have a problem of growing property structures, wherein the weighted average age of the com-

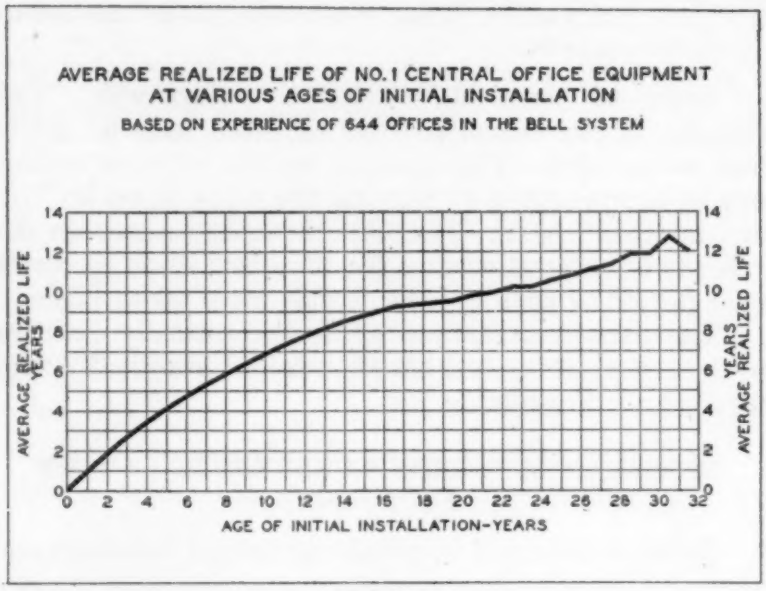

AVERAGE REALIZED LIFE OF NO. 1 CENTRAL OFFICE EQUIPMENT
AT VARIOUS AGES OF INITIAL INSTALLATION
BASED ON EXPERIENCE OF 644 OFFICES IN THE BELL SYSTEM
AVERAGE REALIZED LIFE YEARS
0 2 4 6 8 10 12 14
AGE OF INITIAL INSTALLATION-YEARS
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
AVERAGE REALIZED LIFE YEARS

FIG. 11

ponent units of the structures is much less than the overall age of the structures as operative entities.

Some interesting investigations have demonstrated the relation of average realized life of Central Office equipment to age of initial installation for various ages of the latter, and it has been found that the engineering economics in the advance provision of this class of property set rather definite limitations to the average life of the composite structures, even though the age of the first and oldest portions of the structures may be very lengthy.

In the ordinary classes of telephone property we have groups of homogeneous units, the components of

which arrive together in a given year but gradually and variously waste away.

In the case of Central Office telephone equipment, we have the rather unusual phenomenon of groups of

SOME CAUSES OF ORDINARY DEPRECIATION OF TELEPHONE PLANT AND ILLUSTRATIONS OF THEIR EFFECTS

CAUSES OF DEPRECIATION	KIND OF DEPRECIATION (PREDICTABLE EFFECT)	PLANT CHARACTERISTICS AFFECTED	ILLUSTRATIVE CASES
ACTION OF ELEMENTS	ROT, RUST AND DECAY	PHYSICAL CONDITION	DETERIORATION OF WIRE
ORGANIC AGENCIES	ROT, RUST AND DECAY	PHYSICAL CONDITION	ROTTING OF POLES
USE IN OPERATION	WEAR AND TEAR	PHYSICAL CONDITION	DETERIORATION OF AUTOMOBILES IN USE
INJURY	WEAR AND TEAR	PHYSICAL CONDITION	UNDERGROUND CABLE INJURED BY WORKMAN'S PICK
STORMS AND CASUALTIES	WEAR AND TEAR	PHYSICAL CONDITION	POLES DESTROYED BY SLEET STORM
IMPROVEMENTS IN THE ART	OBSOLESCENCE	FUNCTION	SUBSTITUTION OF CALL INDICATOR POSITIONS FOR MANUAL "B" POSITIONS IN CENTRAL OFFICES
GROWTH OF COMMUNITIES SERVED	INADEQUACY	CAPACITY	SUBSTITUTION OF A LARGER UNIT, SUCH AS A SWITCHBOARD OR CABLE
MORE INTENSIVE SERVICE	INADEQUACY	CAPACITY	SUBSTITUTION OF A LARGER UNIT, SUCH AS A SWITCHBOARD OR CABLE
FIRES	DAMAGE	PHYSICAL CONDITION	BURNING OF STATION APPARATUS IN A BUILDING FIRE
ADVANCING SOCIAL STANDARDS	PUBLIC REQUIREMENTS	CHARACTER AND LOCATION	LINES RETIRED BECAUSE OF PUTTING WIRES UNDERGROUND ON THOROUGHFARES
PUBLIC CONVENIENCE	PUBLIC REQUIREMENTS	CHARACTER AND LOCATION	POLES RETIRED BECAUSE OF HIGHWAY CHANGES

FIG. 12

units which arrive from time to time and are completed in a single structure, no part of which is separable for depreciation purposes because of the mutuality of relation of all of the parts, regardless of age, the entire structure being eventually retired en bloc.

"Ordinary Depreciation" vs. "Extraordinary Depreciation"

In the studies and projections previously referred to, we have been concerned with losses caused by what is generally termed "Ordinary Depreciation." However, there may be certain other operating losses, to which we have not heretofore referred, that might well be classed as "Extraordinary Depreciation."

Fundamental accounting considerations lead us to distinguish four kinds of losses:

First: Losses such as customarily result from the devotion of perishable plant to service through wear and tear, storms and other casualties, inadequacy, obsolescence, etc.; that is, "ordinary depreciation." Reasonable prudence demands proper and adequate provision for the full amount of such losses.

Second: Losses, not the ordinary outcome of use in operations but which are known from the nature of the property, to be at times the outcome of a definite hazard of employment, for example, destruction by fire. Prudence makes such provision proper as is dictated by the nature and extent of the hazard and the contingency of depreciation loss. (In the case of the Bell System, because of the nature of the property and the extraordinary precautions taken to protect the service against interruption, fire losses not covered by underwritten insurance have been of such extremely minor consequence that we prefer to consider them as covered in our provision for ordinary depreciation.)

Third: Extraordinary losses which are not common to the particular property and do not flow from the ordinary hazards of employment, which prudence does not require us to anticipate but which are nevertheless conceivable and for which the accounting system must afford the means of possible depreciation treatment. Losses due to earthquake or war or to some unforeseen revolutionary invention would come under this class. Such losses are too uncertain and remote to admit of advance provision being made by any method sufficiently definite to warrant inclusion of charges as operating expenses and, under these conditions, the blow to the assets, should it occur, must be met temporarily by the company's exist-

> ing surplus, which ought to be maintained, among other things, to enable the company to outride the financial troubles induced by such unforeseen events. Their amortization must be accomplished after the event and in the telephone business we consider that it would be good accounting in order not to distort the current accounting of the time when the blow fell, to charge such losses initially to suspense and to amortize the amount involved, by installment charges, over a reasonable period of time, in a separate account under Operating Expenses to be entitled "Extraordinary Depreciation." If revenues during this process are sufficient for the purpose, the gradual accumulation in the undertaking of additional assets equivalent to the amortization installments will eventually effect a restoration of the surplus.
>
> The fourth species of loss is that which does not affect merely individual items of plant or equivalent in a continuing industry so much as it attacks the industry as a whole. For example, there was the supersession of the wooden ship building industry when iron ships made their appearance. There was the destruction of many bicycle businesses when the automobile arrived. The risk of losses of this sort, which cripple or destroy an industry, not merely items of its equipment, must be covered, if at all, out of current profits. Such risk is one of the general hazards of business to be considered in determining what is an acceptable return from the enterprise.

With this understanding of the limitations of ordinary depreciation accounting, we may say that it covers the losses that culminate upon the retirement of property from service which are occasioned by causes known to become operative in the ordinary conduct of the undertaking and the effects of which can be forecast.

The fact that no account is taken by telephone companies of the possibility of something extraordinary happening does not mean that the eyes of telephone accountants are shut to that possibility. We simply resolve our doubts in favor of a longer rather than a shorter life, until the unforseen shall occur.

Forecasting Service Life and Salvage of Existing Property

The problem of forecasting ordinary life and salvage of telephone plant is not a difficult problem, as business and accounting problems go nowadays. It requires sufficient data, drawn largely from past experience, and the consideration and judgment of competent experts.

The telephone business has certain peculiarities which favor the correct determination of the depreciation factors of service life and salvage.

A telephone company undertakes the provision of the entire service within an area. It operates without competition of similar companies. There is a direct relation between the spread of its service and the growth of population. Telephone plant is so costly and the importance of locating central offices and distributing systems economically with reference to the spread of communities is so immense, that it is the custom of telephone engineers to prepare and continuously maintain for the exchange plants of urban centers and for toll systems, "Fundamental Plans" which look ahead for a certain number of years and furnish a dependable conspectus of the telephone situation, present and prospective, in the area.

Long-lived Property

Certain long-lived properties, such as main conduit runs and buildings of the typical American monumental type offer points of difficulty as to probable service life. The judgment of experts is of special value here and there is always opportunity to restudy the matter as the age of the units increases and the engineers obtain a farther view into the future through the Fundamental Plans. The eventual retirement of such property can be forecast as most probable, therefore a reasonable estimate—even though containing a margin of error—keeps the accounts more nearly cor-

ILLUSTRATION OF METHOD OF DETERMINING ANNUAL DEPRECIATION EXPENSE

CLASS OF PROPERTY	COST	AVERAGE SERVICE LIFE YEARS	GROSS SALVAGE	COST OF REMOVAL	NET SALVAGE		PROPERTY COST USED UP		ANNUAL DEPR. RATE PER CENT	ANNUAL DEPR. EXPENSE
					AMOUNT	% OF COL.2	AMOUNT (COL.2-COL.6)	% OF COL.2	(COL.9÷COL.3)	(COL.2×COL.10)
1	2	3	4	5	6	7	8	9	10	11
BUILDINGS	$ 82,000	30	$ 32,800	$	$ 32,800	40	$ 49,200	60	2	$ 1,640
CENTRAL OFFICE EQUIPMENT	196,000	13	47,040	15,680	31,360	16	164,640	84	6.5	12,740
STATION APPARATUS	78,000	5	54,600		54,600	70	23,400	30	6	4,680
PRIVATE BRANCH EXCHANGES	32,000	6	22,080	1,600	20,480	64	11,520	36	6	1,920
BOOTHS	4,000	6	2,760	200	2,560	64	1,440	36	6	240
EXCHANGE POLE LINES	67,000	13				0	67,000	100	8	5,360
EXCHANGE AERIAL CABLE	64,000	14	24,320	9,600	14,720	23	49,280	77	5.5	3,520
EXCHANGE AERIAL WIRE	53,000	11	21,200	7,950	13,250	25	39,750	75	6.8	3,604
EXCH. UNDERGROUND COND.	82,000	50				0	82,000	100	2	1,640
EXCH. UNDERGROUND CABLE	110,000	18.5	55,000	16,500	38,500	35	71,500	65	3.5	3,850
EXCH. SUBMARINE CABLE	1,300	12.5				0	1,300	100	8	104
TOLL POLE LINES	75,000	16.5				0	75,000	100	6.1	4,575
TOLL AERIAL CABLE	10,000	14	4,500	1,500	3,000	30	7,000	70	5	500
TOLL AERIAL WIRE	77,000	20	34,650	11,550	23,100	30	53,900	70	3.5	2,695
TOLL UNDERGROUND COND.	9,000	60				0	9,000	100	1.7	153
TOLL UNDERGROUND CABLE	19,000	25	10,450	2,850	7,600	40	11,400	60	2.4	456
TOLL SUBMARINE CABLE	1,000	12.5				0	1,000	100	8	80
FURNITURE AND FIXTURES	7,000	10	1,400		1,400	20	5,600	80	8	560
SHOP EQUIPMENT	100	10	20		20	20	80	80	8	8
STORE EQUIPMENT	600	10	120		120	20	480	80	8	48
GARAGE EQUIPMENT	8,000	5	2,000		2,000	25	6,000	75	15	1,200
TOOLS AND IMPLEMENTS	4,000	4	800		800	20	3,200	80	20	800
RIGHT OF WAY-EXCH.	5,000	30				0	5,000	100	3.3	165
RIGHT OF WAY-TOLL	7,000	40				0	7,000	100	2.5	175
INTEREST DURING CONSTRN	8,000						8,000	100	5.1	409
TOTAL	$1,000,000		$313,740	$67,430	$246,310		$ 753,690			$ 51,122

-COMPOSITE RATE-

(A) TOTAL INVESTMENT $1,000,000 (B) TOTAL ANNUAL DEPRECIATION EXPENSE $51,122

(C) COMPOSITE DEPRECIATION RATE (B÷A) 5.11%

FIG. 13

rect from year to year than if a heavy retirement liability be conveyed to the future without any provision to meet it.

Salvage

The factor of salvage in telephone depreciation has been successfully dealt with in practice. A study recently made of plant retired, salvage on which was allowed for in the computation of depreciation rates to the amount of $122,594,000, revealed that the net salvage actually realized was $122,499,000. The chief problem in the treatment of salvage, especially for the longer-lived property, is one of secular variation in cost levels. Index number studies are very helpful in interpreting the records of the past as shown in the accounts. Existing market prices of junk material are helpful. Price changes in the future may properly be considered, if a fairly definite forecast can be made, but resort to speculation is not advisable.

The Rôle of Judgment

The proper interpretation of the data regarding plant life and salvage obtainable from accounts, records and statistics is of equal importance with the integrity of the data themselves. It would seem that we should have first: investigations of past service life and salvage through sound accounting and statistical methods; second: investigations of the conditions surrounding the employment of such plant in the past and of the extent to which such conditions still prevail; third: the best possible forecast of conditions looming in the future which should exert a modifying influence upon either life or salvage. And then, the active judgment which fuses the experience of the past, so far as it is still pertinent, and the expectation for the future, so far as it is presently pertinent, into a just and reasonable determination of the current rate of depreciation for the time being.

The ascertainment and interpretations of the facts

and the making of the expert opinions and estimates must be undertaken by persons thoroughly familiar with the property and conversant with the future plans of the management. The company's future policy and program are intimately bound up with this undertak-

DEPRECIATION RATES FOR A LARGE TELEPHONE COMPANY IN THE UNITED STATES

PORTION OF PROPERTY	DEPRECIATION RATES %
EXCHANGE RIGHT-OF-WAY	5.0
TOLL RIGHT-OF-WAY	2.5
BUILDINGS	2.1
C.O. EQUIPMENT - MANUAL	8.5
- PANEL	6.0
- STEP-BY-STEP	6.0
OTHER EQUIPMENT OF C.O.	8.0
STATION APPARATUS	4.5
STATION INSTALLATIONS	1.0
INTERIOR BLOCK WIRES	4.0
PRIVATE BRANCH EXCHANGES	5.0
BOOTHS AND SPECIAL FITTINGS	3.6
EXCHANGE POLE LINES	7.5
EXCHANGE AERIAL CABLE	6.2
EXCHANGE AERIAL WIRE	7.6
EXCHANGE UNDERGROUND CONDUIT - MAIN	2.0
- SUBSIDIARY	4.0
EXCHANGE UNDERGROUND CABLE - MAIN	2.5
- SUBSIDIARY	6.0
EXCHANGE SUBMARINE CABLE	7.0
TOLL POLE LINES	6.0
TOLL AERIAL CABLE	4.0
TOLL AERIAL WIRE	4.8
TOLL UNDERGROUND CONDUIT	2.0
TOLL UNDERGROUND CABLE	2.5
TOLL SUBMARINE CABLE	7.0
OFFICE FURNITURE AND FIXTURES	7.0
COMPOSITE RATE FOR COMPANY	5.05

FIG. 14

ing. Fundamentally, the determination of the proper rate is a problem of management; there can be no machine solution of it.

THE DEPRECIATION RESERVE ACCOUNT

Passing now to another phase of the subject; i.e., the depreciation reserve account in the balance sheet,

which arises as a result of the accrued depreciation charges in the Income Statement.

In its origin, the "Reserve for Depreciation" account is merely the reflection under a system of double entry bookkeeping of what remains in the liabilities from the past charges for depreciation expense. The entry of prime importance is the charge to expense, which could be made equally as well under single entry bookkeeping; such a charge would be sufficient in itself to insure correct accounting. The expense charge serves the fundamentally important and useful purpose of debiting to any year or other accounting period recognized by the accounting, one of the costs of rendering telephone service during that period, namely the expense of depreciation. The total cost of that service cannot be inclusive without the item of depreciation. Along with this fundamental proposition of stating depreciation costs in periods in which they should be stated in order that the expense accounts may reflect true costs, goes the point that this procedure has the advantage of substantially equalizing the effect of property retirements. It is, of course, desirable that there be reasonable equalization, but this effect of depreciation accounting is merely a collateral effect of steps taken primarily to accomplish the purpose of spreading the retirement costs equitably over the service life to the depreciating property.

However, because double entry bookkeeping is employed and because the balance sheets of corporations which have become so important in modern times are a product of the double entry system, the reserve for depreciation, as a liability account, of itself comes to serve some important and useful purposes.

Advantages of Reserve Accounting

As an accounting consideration, the reserve account exhibits the accumulating provision for retirement of existing plant, which remains after charging off the loss

on items that have already been retired from service. In the same way, the reserve of a life insurance company represents the provision for meeting the accumulating liability which will mature upon the death of its policyholders.

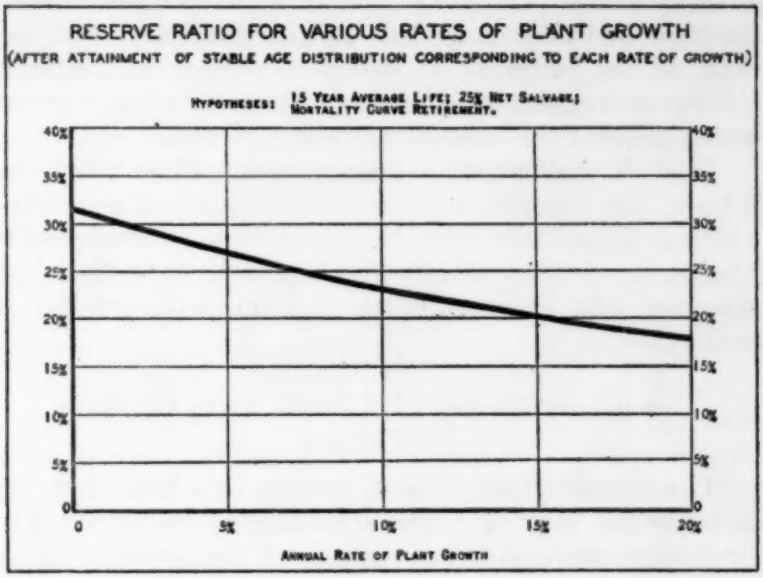


FIG. 15

As business considerations, several advantages of the reserve account appear. An adequate reserve account appearing in the balance sheet is a sign that the integrity of the company's assets is being maintained. The appearance of the account in this way before investors assists the companies to attract capital for extensions and betterments on favorable terms and as a result of these features, the depreciation reserve account assists a company to maintain service to its users with economy and in a high-grade manner.

ACCURACY OF THE RESERVE ACCOUNT

In the course of years the reserve account assumes a prominent place in the balance sheet, and sooner or

later it may become a matter of concern to know that it is reasonably correct. For this reason a knowledge of the characteristics of reserve growth is important. For any particular group of property installed at a given time the reserve account must, of course, increase steadily at first, reaching its maximum in dollars about the time of the average life and its maximum as a per cent. of the property to which it relates immediately before retirement of those components of the group which achieve the longest individual lives.

For all groups of a homogeneous class taken together, the reserve account will exhibit a condition which is dependent upon the complex of the successive groups, upon their relative volume and upon their appearance and disappearance in time with respect to each other.

Theory of the Reserve Account in Growing Properties

The introduction of new groups into the class will decrease the reserve ratio: the ratio of the amount of the reserve account to the amount of the property class. Reserve ratios are lower in growing than in non-growing properties, other conditions being the same. Disregarding oscillations, a long continued uniform rate of growth tends to produce a stabilization of the reserve ratio, at a point dependent upon the particular rate of growth. If the rate of growth later increases, the reserve ratio becomes lower and will tend to stabilize at the lower figure as long as the higher rate of growth continues.

Theory of Reserve Account in Non-growing Properties

A condition of non-growth in a continuing property eventually brings about, after a stable age distribution is achieved, a reserve ratio at the highest point obtainable in a non-disappearing plant with stable age distri-

bution. If units were always retired at the point of the average life (i.e. if they all had the same age at time of retirement), this highest ratio would be, with no salvage .50, or, with salvage, one-half of the sum derived by subtracting the ratio of salvage from 1.00, but with distributed retirements, the highest ratio must always be less than .50, for the loss of those members of the group which perish before the term of the average life occasions a greater reduction, percentagewise, in the reserve account to which their loss is charged than in the property from which their original cost is subtracted.

Effects of Group Basis of Accrual

Group accrual does not provide for the entire loss of short-lived components during their individual lives; the accrual must be carried out on the longer-lived components to the end of their lives and beyond the midpoint representing the average life of all components, in order to provide for the entire loss of the group as such. For this reason, it is not possible to reckon up from an examination of the ages of items presently in service how much should stand in the reserve account in respect of such items.

Retirement Expense Less Than Depreciation in Growing Properties

A knowledge of the characteristics of the ratios of current annual retirements (which are the annual gross debits to the reserve account), to the straight-line accruals for depreciation in the same year is also desirable.

In a growing plant, the annual retirement losses will be less than the current true annual expense of depreciation and the greater the rate of growth, the smaller the retirement losses will appear in comparison with the current depreciation rate, the reason being, of course, that in a growing plant there are new plant groups in operation on which depreciation is accruing

but which are not yet represented, or are but slightly represented, in the retirement losses. If we conceive of a rapidly growing plant in three successive stages of its existence, such stages being representative of a period of turnover of the plant, designated A, B and C, then, speaking in averages, the retirements during B will relate for the most part to the smaller plant A,

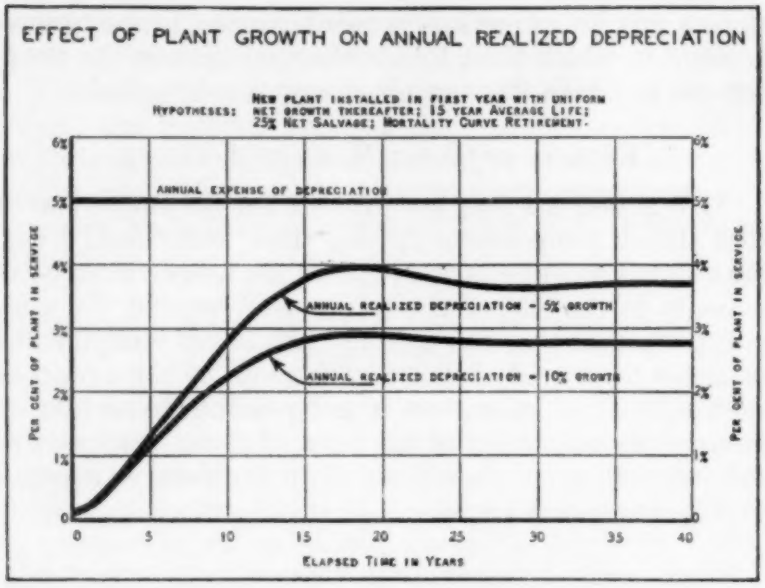


FIG. 16

while the depreciation reserve account is currently building up to meet the greatly increased eventual retirement liability of B. Similarly in period C retirements will relate to the smaller plant B, while the accruals now relate to the greater plant C. For this reason any attempt to ascertain percentages of current depreciation expense to investment in a growing property by dividing the average retirement losses by the average plant in service during the period within which such losses culminate, involves a mathematical fallacy.

Obstacles to Employment of Straight-Line Method

In all that has been said so far, the practicability and indeed the desirability of the straight-line method for depreciation expense accounting has been taken for granted, but obstacles to the use of this method undoubtedly exist in some cases. The obstacles usually appearing are:

Inability to set up a line of demarcation between current maintenance and depreciation. It would seem possible generally, though perhaps not universally, to overcome this difficulty by the adoption of a system of units of property, the retirement of which would be depreciation, work on which while in service, including replacements of parts, would be current maintenance. Under this plan, minor parts would be charged as depreciation only as originally embodied in the unit of which they were a part at the time of its installation and would be written off to reserve as an undivided part of the retirement loss of the unit, when the unit is removed or abandoned.

Difficulties in forecasting service life. This obstacle may in some cases appear serious, but in most instances it is unduly magnified. Most accountants probably would agree that the difficulty of accounting does not warrant entire neglect of accruing depreciation. It is the duty of a company to manage its business well and sound management may require, in many cases, ample provision for an inevitable loss, uncertain merely as to the time of its incidence. If provision should be made on some basis, probably a straight-line treatment, even with a considerable margin of error in the initial assumptions, would be reasonable, the matter to be periodically reexamined. Is it not a good rule that where difficulties in ascertaining accounting values are largely inherent in the nature of the subject-matter, the accounting should nevertheless go forward, the factors involved to be determined arbitrarily by the use of judgment, as nearly as may be?

In a number of industries, it has been considered that the straight-line method does not afford sufficient protection against unanticipated depreciation, due to unforseen progress in the art, exigencies of competition, etc., and the reducing balance method has been adopted. One factor here is whether the nature of the enterprise is such that amortization in arrears of extraordinary casualty damage, sudden major obsolescence or losses on unanticipated reconstruction, is possible without too great risk or detriment. Certainly, risky and uncertain enterprises and those in a rapidly evolving state due to revolutionary inventions or discoveries, if

they apply the straight-line method, may very well reverse the ordinary course, and resolve their doubts, in the early years of use of plant units, in favor of a shorter rather than a longer life.

In Conclusion

Within the lifetime of our older accountants; the depreciation charge has been successively characterized as improper, then legitimate, and lastly as necessary. There are but few now who contend that the depreciation charge is improper; its legitimacy is generally recognized. Not all agree that it should be compulsory. As regards telephone companies, the straight-line basis is generally believed to be in the best interest of the companies as regulated undertakings, and of the public which they serve, and it is compulsory by law.

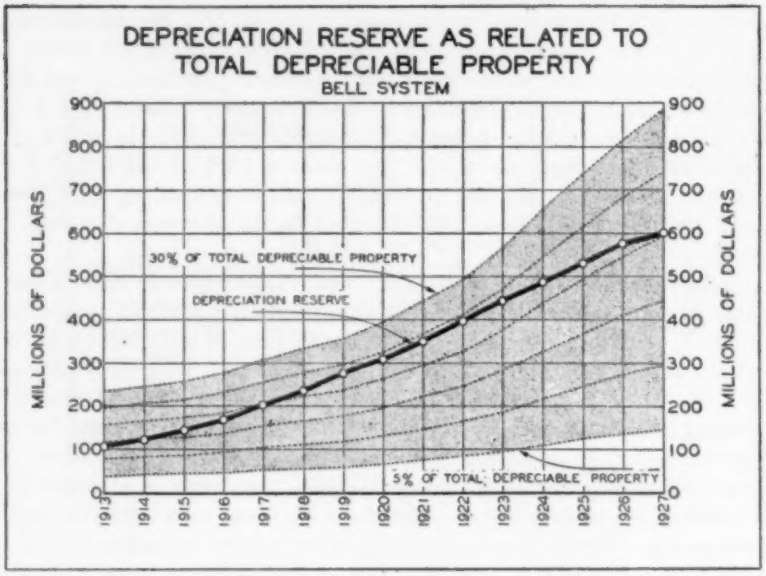


Fig. 17

It is unwise to become dogmatic regarding the treatment of depreciation because the question presents so many different aspects as viewed from different industries, with their varied histories and traditions, prac-

tices, and prospects. Any accounting method which generally commends itself as a fair method to those interested in an industry of a particular type is worthy of a fair hearing and if it has worked well, it should not be lightly overturned. Nevertheless, there cannot be more than one set of sound accounting principles. This makes necessary mutual agreement upon the fundamentals, upon definitions and the use of terms, without which arguments become confused and the meeting of minds impossible. When the terms employed are made susceptible of but one meaning, it may be possible to secure general agreement as to principles, and the application of sound principles to highly various industrial fields of operations may well result in a variety of treatments which are salutary and practicable in certain fields to which suited, but impracticable or inadvisable elsewhere.

In the telephone business in the United States, the suitability of the straight-line depreciation accounting practice has been tested and demonstrated by long experience.

ALLAN B. CRUNDEN,
DONALD R. BELCHER.

Editor's Note: Mr. Crunden is Assistant Comptroller and Mr. Belcher is Assistant Chief Statistician of the American Telephone and Telegraph Company.

Installation of New Types of Buried Toll Cable

Abstracted in part from a paper presented at the Bell System Engineering Conference, June, 1929, by C. W. Mier and B. D. Hull of the Southwestern Bell Telephone Company

THE toll lines of the Bell System consist of two general types, open wire and cable, depending largely upon the number of circuits required along a given route and the rate of growth. When cable has been employed it has been installed either on a pole line or in conduit, the conduit usually being placed under or closely parallel to highways, inasmuch as accessibility to such large units of plant is important from the standpoints of construction and maintenance. Aerial cables are, however, frequently installed along private rights-of-way and this, of course, results in shortening the route.

The recent rapid growth in toll traffic has required the installation of cables throughout constantly widening areas, where a few years ago the traffic was adequately handled over open wire lines. On many of the routes in these areas, conduit could not be justified so that cable on pole lines would normally have been employed. Realizing, however, that there would be advantages in underground installations, considerable study was devoted to the problem of finding a cheaper method of placing cables underground, that would be applicable to these routes. This problem has been solved by the introduction of two methods of installation that are new to the Bell System.

One of these methods employs a cable buried in the ground, without conduit. The lead covered cable used for such installations is manufactured with protective coverings of impregnated paper, jute and steel tape,

which safeguard the sheath of the cable from subsequent soil corrosion and from mechanical damage. The other method, which conforms more nearly to established practices, consists in laying a single fiber conduit and pulling the usual type of lead-covered cable into it by means of the power winch line. In both cases, manholes are constructed at loading points only, and thus about 90 per cent of the manholes employed in the more usual conduit structure are omitted.

Inasmuch as these types of installation are new, it was necessary to develop entirely new procedures for the construction work and in this connection a very important element has been the extensive use of labor-saving machinery, making it possible to carry out the work expeditiously and at relatively low costs. Much of this machinery has been developed for this specific purpose by Bell System engineers and in other cases it was necessary to adapt commercial machinery to meet the requirements of this work.

Survey and Clearing Right-of-Way

In general, buried toll cable is located on private property which usually permits the selection of the shortest possible route.

In some cases it has been found desirable to make aeroplane photographs to assist in selecting the route along which the preliminary survey will be made. Such pictures assist materially, particularly through areas where the terrain is broken and wooded, inasmuch as in such locations the selection of a satisfactory route would otherwise be extremely difficult.

After the route has been selected and surveyed, it is necessary to clear it of trees and other obstructions sufficiently to permit the movement of construction machinery incident to digging the trench, delivering and placing the cable and loading coil cases, and backfilling. Clearing the right-of-way is done by means of caterpillar tractors, scrapers, power graders, and in some

cases it is necessary to also employ compressed air equipment.

Shipping the Cable

Both the tape armored cable and the cable to be installed in fiber conduit are shipped in lengths of about 755 feet. For the tape armored cable which in the size now being installed is about 60 per cent heavier than the ordinary lead-covered cable, a steel reel is used. This reel, with its load of cable, weighs about 5 tons. Shipments from the factory are made by either boat or rail or a combination of both, depending upon the point of destination.

It will be noted that sufficient room is left at the end of the loaded car to permit turning the reels in case it is necessary to unload them from the side of the car.

Delivering Cable from Railroad Cars

Wherever practicable the reels of cable are unloaded by rolling them out over the end of the car to the platform of a truck.

However, conditions are met where it is necessary to unload the cable from the car to the ground, in order to store it until the truck deliveries can be made.

For this condition it is usually necessary to locate the power winch equipped truck on the same side of the track as that upon which the reels are to be lowered. The power winch line is threaded under the car, through a special tackle and over the platform of the car to a yoke which lowers the reel over heavy skids to the ground.

Delivering Reels of Cable to the Job

Two methods are in use for delivering cable to locations on private property. The more recent and faster method is to employ a heavy-duty four-wheel-drive truck equipped with a 100 horse-power engine.

Dual pneumatic tires of the largest size now commercially available are used on the rear wheels of this truck. On the front wheels dual tires are also used, the inside tires being of the same size as those on the rear wheels and the outside tires of somewhat smaller diameter and width. This arrangement of tires on the front wheels permits of easy steering on hard surfaced roads and the smaller outside tires come into action immediately when soft ground is encountered. Trucks of this kind have performed satisfactorily both in mountainous territory and where very muddy or sandy conditions had to be negotiated.

The other method of delivering cable to private property consists in moving it as far as practicable with rear wheel drive truck equipment, and then taking it across the private property on trailers equipped with caterpillar tracks and drawn by caterpillar tractors.

Both the four-wheel-drive truck and caterpillar tractor-trailer methods of cable delivery are satisfactory. However, the truck has the advantage of being able to travel at a speed of about 20 miles per hour whereas the tractors make a speed of only four miles per hour.

Digging the Trench

In ordinary soil a trenching machine of the type illustrated can be operated satisfactorily.

A machine of this type will dig a trench about 15 inches wide and 30 inches deep, such as is required, at the rate of from one-half to one mile per day, depending upon the conditions encountered. It will not, of course, dig through solid rock. However, some soil formations have been excavated, which contained a great deal of rock.

Where much rock is encountered a very ragged trench results. However, the saving due to the use of machinery as compared with hand labor, under such conditions, is very great.

Where the rock contains numerous seams and

weather checks, it is possible in some cases to cut a trench through it by means of a tractor plow. This outfit can also be used in loam or sand but will not dig nearly so deep as the trenching machine. The plow cuts a furrow and partially clears it, the final clearing of the trench being accomplished by means of manual digging.

Where the rock is too hard or too solid for the trenching machine or tractor plow, compressed air equipment is used.

The air compressors for this class of work are mounted on trucks in order to give them maximum portability. The largest tires which can be applied to the truck are used, so that it will negotiate as much of the private right-of-way as possible, with its own motive power. Where this is not possible, it is towed behind a tractor.

Laying Tape-Armored Cable

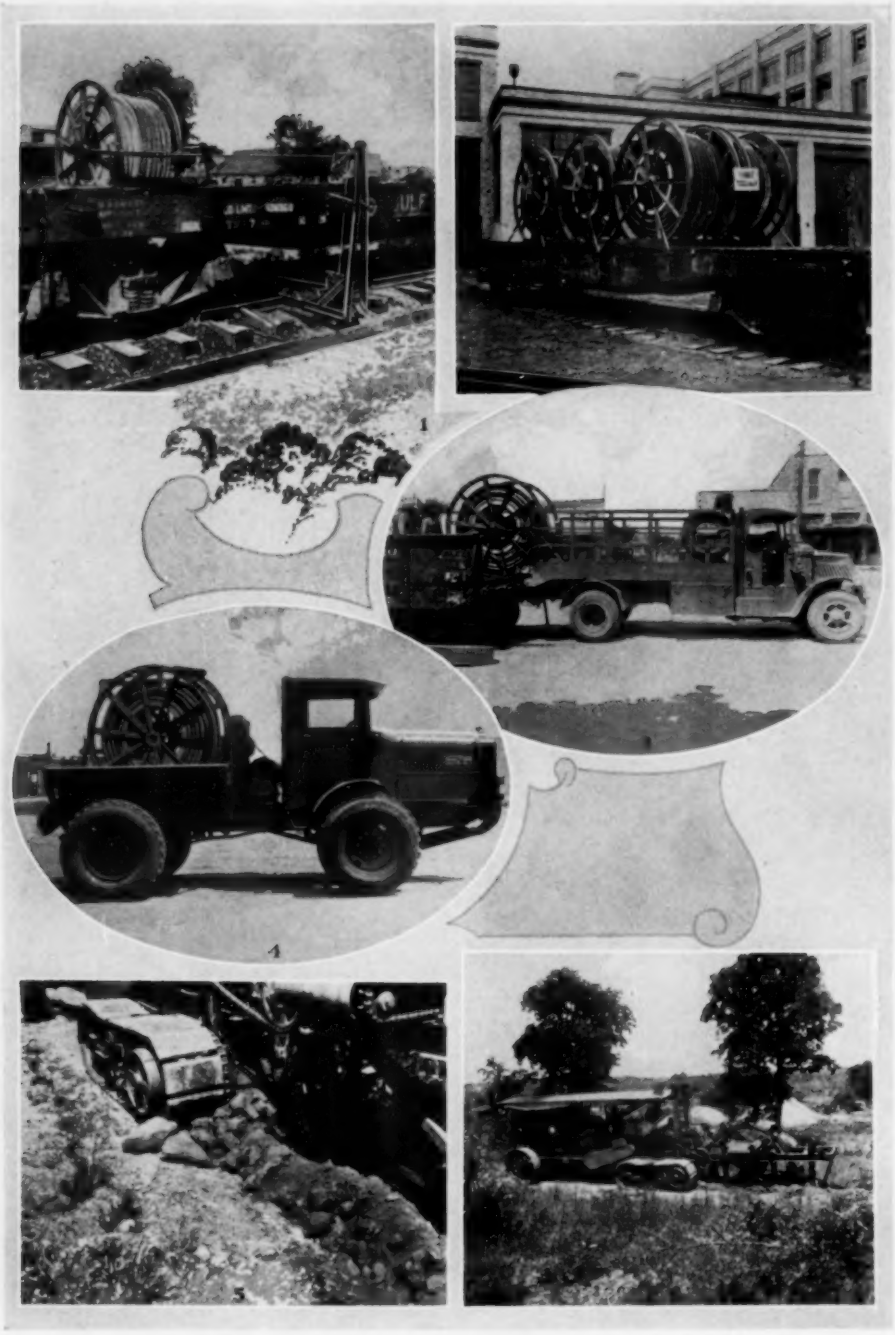
The method most generally used thus far, for laying the tape-armored cable in the trench, has been to feed it off the rear of a caterpillar type trailer. The tractor and trailer, due to their long broad tracks, can operate astride the open trench, lay off the cable from the reel while running along at a speed of about 3 miles per hour and again cross over carrying the empty reel, without injury to the trench or machinery, except in very soft or sandy soil.

Where the traveling conditions permit, two reels are delivered per trip. The cable is first fed off the rear trailer, then from the front one by leading it over the empty reel at the rear.

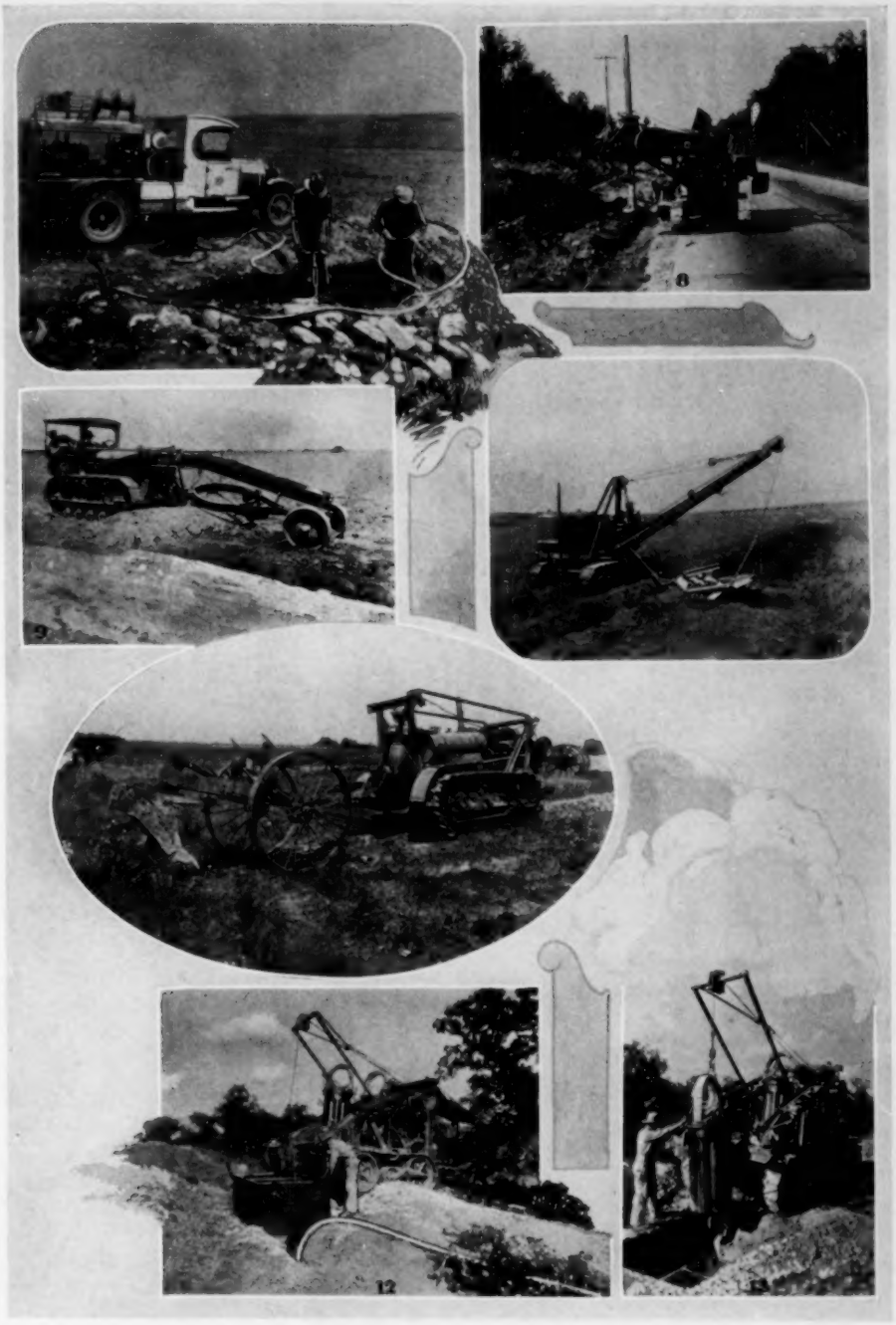
Locations are encountered along the trench where it is not possible to lay the cable direct from the reel. For such locations trench rollers are used and the cable is pulled into the trench over these rollers by means of a power winch line.

By using the trench rollers, the cable can be pulled

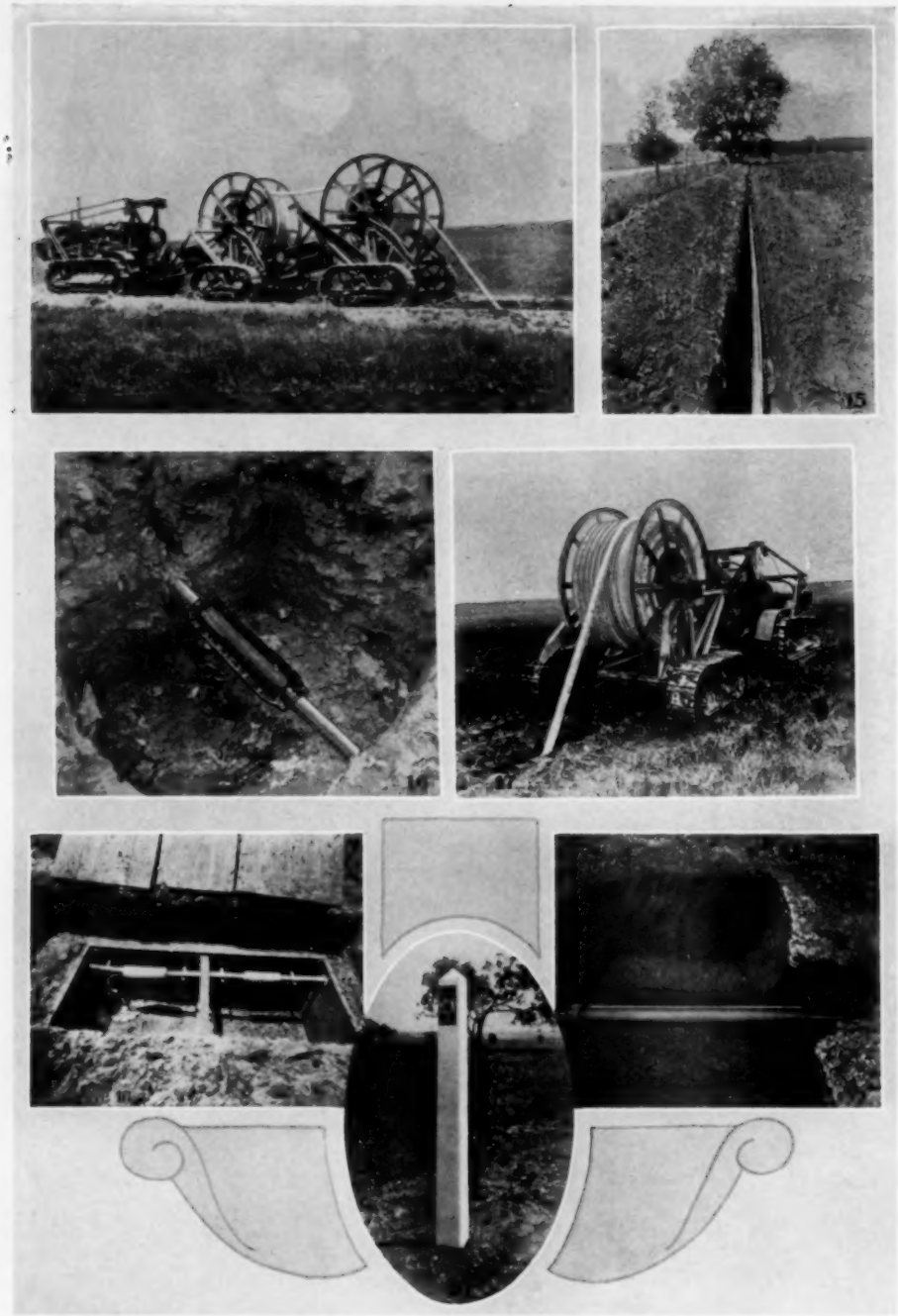
AEROPLANE PHOTOGRAPH OF PROPOSED ROUTE



1. Railroad Car Unloading Tackle.
2. Carload of Tape Armored Cable Ready to Leave Kearny Plant of Western Electric Co.
3. Transferring Cable Reels from Railroad Car to Truck.
4. Four-Wheel Drive Cable Delivery Truck.
5. Trenching Soil which is Full of Flint Rock.
6. Trenching Machine.



7. Excavating with Compressed Air.
8. Mechanical Tamper.
9. Scraper Type Back Filler.
10. Drag Line Back Filler.
11. Tractor Plow Outfit.
12. Lowering Wooden Manhole into Excavation.
13. Lowering Loading Coil Case into Manhole.



14. Double Trailer Outfit.
15. Trench Rollers.
16. Splice Case for Tape Armored Cable.
17. Laying Cable from Caterpillar Trailer.
18. Arrangement of Cable in Loading Manhole.
19. Splice Covering for Cable in Fiber Conduit.
20. Concrete Post Marking the Location of Buried Cable.

under crossing pipe lines, highway pavements, railroads, etc. The trench rollers are also used where soft or sandy soil is encountered which would not support the tractor and trailer over the trench.

Back-Filling

Where the excavated soil is on one side of the trench as in trenching machine operation, the drag line type of back-filler is applicable. This machine rapidly pulls the dirt into the trench, a scoop full at a time, as it moves along the side opposite the spoil pile.

A trench made by the plow has, of course, two small spoil piles, one on each side of the trench. For this condition a back-filler of the scraper type is used.

Tamping

Where a trench is located along a highway, it is ordinarily necessary to tamp the back-filled earth. On private property, the usual practice is to pile a ridge of dirt over the filled trench, then leave it for the rain to settle. However, if tamping is required, the same types of machines are applicable as for the highway work.

Very few obstructions such as pipes crossing the trench are encountered in buried cable installations, due to the fact that they are not made in thickly settled areas. The mechanical type of tamper is best adapted to this kind of work because of its greater speed. However, an equally good, although somewhat slower job of tamping can be done with compressed air tools which are better suited for tamping around pipes or other obstructions.

Splices in Buried Cables

At the locations of splices between consecutive lengths of cable, other than at loading points, manholes are not used. The trench is widened and deepened to provide working space for the splicers and testers.

It is, of course, necessary to remove the tape armor and jute servings from the ends of tape armored cable,

before splicing it. The splice is then made in the usual manner, and subsequently, a cast iron splice case, made in two halves, is bolted over the splice. Each end of the case extends over the tape armor. This case which is filled with a waterproof compound, protects the splice against mechanical damage.

In the case of the cable in fiber conduit, an opening is left between the consecutive lengths of conduit at the splice points, and the splice made between these lengths. Upon completion of the splice a fiber sleeve is slipped over it, overlapping the ends of the fiber conduit. Ring wedges, also made of fiber, are driven in at the ends of the fiber sleeve and serve to hold it in place as well as to prevent the entrance of soil and water.

Pressure Testing

An interesting innovation in the case of the tape armored cable consists in having the cable shipped from the factory with gas pressure in each length. The ends of the length of cable are equipped with valves that permit the pressure to be read, by means of a portable gauge, this being done before the cable is laid and the trench back-filled. Upon completion of the splicing, gas pressure tests are applied in the usual manner to both types of cable to ensure the integrity of the sheath and wiped joints.

Loading Manholes

The manholes at loading points are installed at such a depth that the roof is about two feet below the surface of the ground. No manhole opening is used, the soil being replaced over the roof so as to permit agricultural operations to be carried on. The roof of the manhole is made in sections which can be lifted off when occasion requires the manhole to be entered subsequent to the initial installation and thus provide space in which to work. It will, of course, be necessary to excavate the soil from above the manhole to enter it, but it is ex-

pected that necessity for this will arise only infrequently. No floors are used, the loading coil cases being buried in the earth bottoms of the manholes.

Since many of the manholes are located in private property where they will not be required to support the heavy loads imposed upon manholes located under highways, they are sometimes built of creosoted wood planks. In such cases the manhole is assembled above ground at the point where it is to be used and lowered into the excavation by means of a power derrick.

The special derrick equipment used for lowering the wooden manholes is also employed in handling the heavy loading coil cases subsequently installed in the manholes. The derrick is so arranged that it can be lifted to any desired position and the loading pot raised or lowered independently. The motor vehicle shown handling the manhole and loading coil cases is equipped with removable tracks which can be placed around the wheels when it is desired to negotiate soft ground.

As will be noted in the illustration, the first loading coil case is installed in a corner of the manhole and later a second case will be placed in the corner at the opposite end, where the stub cable can be brought into the main cable in a second splice.

Markers

While the cable generally traverses private property where there would be little likelihood of its being disturbed and damaged by subsequent excavations, this is not always true where it crosses highways. Consequently, at such points the cable is laid at a depth of about four feet, and at each side of the road a concrete post is set to indicate the location of the cable. A sign mounted on each post so placed, warns persons who might be engaged in excavating activities along the road not to disturb the cable. Similar posts are set at property lines intersecting the route of the cable and at other points so as to assist the maintenance forces in locating

the cable. Each of these posts carries a copper plate on which is inscribed the serial number of the post, thus affording association with the post locations on the map record, and also other pertinent information, such as the distance from the post to the cable.

In a short article such as this it is, of course, impossible to cover the many details which must necessarily be worked out by the engineering and construction forces. These types of installation are now just getting under way, and while there has been only a comparatively small amount of buried cable placed up to the present time, plans are now being made for a number of additional installations. As more experience is gained with this type of construction, new developments and refinements will doubtless be made in the heavy handling machinery and in the methods. However, due to the general interest in buried cable, this short review is given to indicate what is being done at the present time.

Long Distance Telephony in Europe

Foreword

WITH the opening of transatlantic telephone service, international long distance telephony took on a new aspect. The provision of a telephone link between the Old World and the New might be considered the opening phase of intercontinental and world wide telephony. In the following article, Dr. King describes progress made in the extension and improvement of the long distance telephone service in the Old World and the important co-ordinating influence of the International Consulting Committee for Long Distance Telephony in Europe known as the C. C. I. Since the opening of transatlantic telephone service between England and the United States in 1927, additional channels of communication have been added and telephone users in the United States now have telephone access to most of the important countries of Europe as well as to Cuba, Mexico and Canada. The development of international telephony on a world-wide basis requires that we of the Bell System have an understanding of and a friendly interest in the telephone problems of other nations, and as one means to this end, the American Telephone and Telegraph Company is associating itself with the work of the C. C. I. The organization and functions of the C. C. I. will be explained in a subsequent article. The author, Dr. R. W. King is a member of the staff of the technical representatives in London of the American Telephone and Telegraph Company. The Editor.

Long Distance Telephony in Europe

We in the United States have always stressed the importance of nation-wide telephone service and are now proud of the fact that the present scope of our communication system is not even limited by our national boundaries but embraces the greater part of the

telephone-using World. The opening of transatlantic service in January, 1927, marked a new epoch in telephonic progress. The calls that pass to and fro over the three transatlantic circuits average upward of 1200 per month—a ten-fold increase in traffic since the initiation of this service—and naturally constitute a very

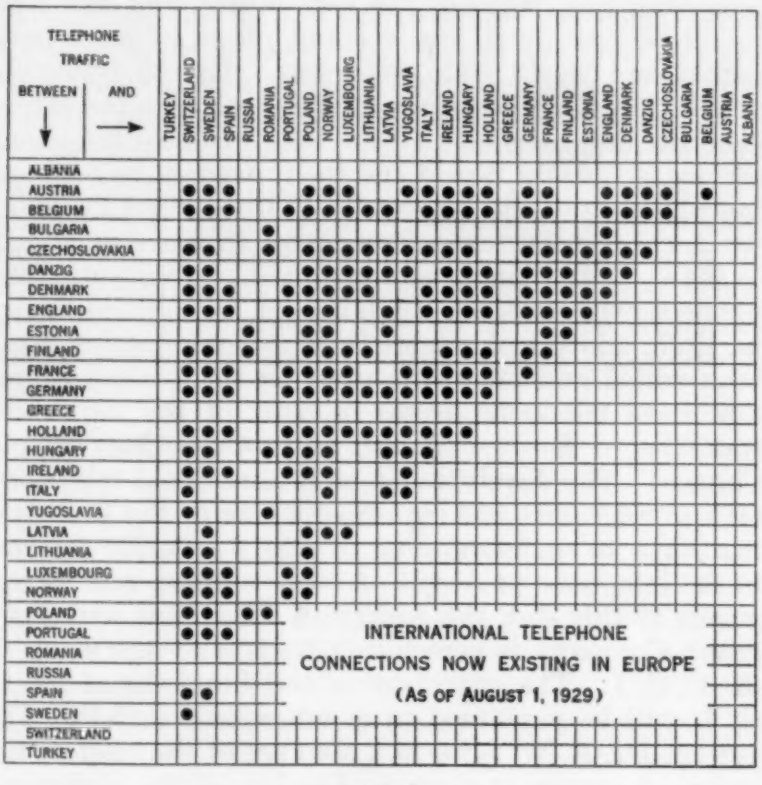


FIGURE 1

substantial basis for American interest in European telephony.

A complete description of long distance telephony in Europe would be far beyond the scope of a single article, and of the various angles from which it might be treated, an introductory discussion may well be limited to a consideration of the inherent difficulties that

have opposed long distance telephone development on the eastern side of the Atlantic, and the extent to which these have been overcome.

Long Distance Calls in Europe

Considering the peculiar difficulties that have had to be overcome, the developments of the last four or five years in long distance telephony between the leading nations of Europe are remarkable. The network of international connections now embraces all of western Europe, as is indicated in the accompanying chart, Fig. 1, and the nations of eastern Europe are rapidly being connected in.

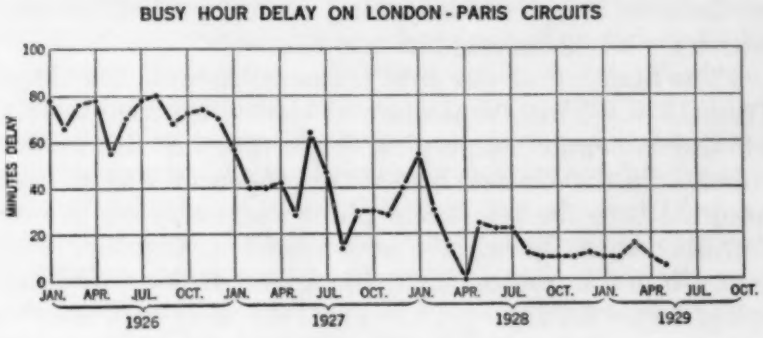


FIGURE 2

Nor do these connections represent only single lines or small groups of lines so burdened with traffic as to make exasperating delays the common rule. It is well recognized in Europe that speed of service and a reasonable rate stand equally in importance with good wire connections. In all of these respects most creditable progress is being made. Delays have been everywhere reduced during the last three or four years; on most of the main international routes cuts range from a reduction of from one-half to one-fifth of the time previously required, and even more. On the London-Paris circuits (of which there are twenty-two now) the average

busy-hour delay has been reduced from an average of seventy minutes in 1926 to twelve minutes for the first half of 1929. During this same period traffic has risen from about 1000 calls a day to about 1600, an increase of over 50 percent. The month-to-month variations of delay are shown in detail in Fig. 2.

On the long routes, say, over 500 miles, which were available three or four years ago, delays of one and a half or two hours on calls booked in the morning were an everyday occurrence. Delays of this character are now quite exceptional.

The progress that the telephone has made in Europe within the last few years is remarkable when considered by itself, but it becomes much more remarkable when we bear in mind the imposing phalanx of difficulties which its advancement has had to meet.

The opening of our first transcontinental line dates from 1915. This event marked the commercial advent of the repeater employing high-vacuum thermionic tubes. In the United States this repeater was at once adopted into the telephone plant and everyone is now familiar with the wholly new aspect it, together with many other improvements, has given to long distance telephony. In Europe, however, the War was then in progress and not for another five years at least had international relations approached sufficiently near normal that the building and operation of new international telephone lines could be contemplated. Long distance telephony as we understand it in terms of the present technique dates therefore in Europe from about 1920 and its span of life has been a scant two-thirds of that it has enjoyed in the United States. As a matter of fact, there were until as late as 1925 very few international agreements regarding the building of telephone lines across national boundaries and the exchange of telephone traffic. However, those who have acted in Europe as advisers and directors for the telephone have worked so effectively that the service is fast approaching the most up-to-date standards.

European telephony is today a splendid example of friendly international co-operation. Each nation builds and maintains all lines within its boundaries whether these are used for internal or for through ("transit") calls. Not only the question of the number of through circuits which any nation supplies to neighbouring nations is subject in the last analysis to its own decision without interference from without, but this is equally true of the myriad electrical factors or properties of each of its telephone lines. Were each nation to take a purely selfish view, determining these factors on a nationalistic basis and without regard to the telephone networks in nearby countries, the physical, and therefore the fundamental, basis of long distance telephony would vanish, and any attempts at international communication by word of mouth would be largely frustrated. A remarkable spirit of give-and-take has prevailed and thanks to certain unifying influences, the more important of which will be discussed presently, Europe now possesses a notable international telephone plant. Today one can ask for a connection from London to Paris, Geneva, Berlin or Stockholm—merely to mention typical cases, with assurance of having a circuit of very satisfactory clearness placed at his disposal.

As typical of the growth of international traffic, Figure 3 shows the trend of calls between England and France, England and Germany, and England and Switzerland.

Some of the most important long distance lines in Europe cross intermediate countries and their construction and operation require an international point of view and noteworthy international co-operation. Thus, lines between England and Germany must cross either Belgium or Holland and the portion of each circuit lying within the boundaries of the transit country is built and maintained by that country. The Telephone Administration of the transit country is the final arbiter as to the number of through lines it will provide

and the rates it will charge for their use. Transit countries, therefore, play a very fundamental part in determining the quality of international service and good service requires that each such country provide an adequate number of lines for other countries' traffic on acceptable terms.

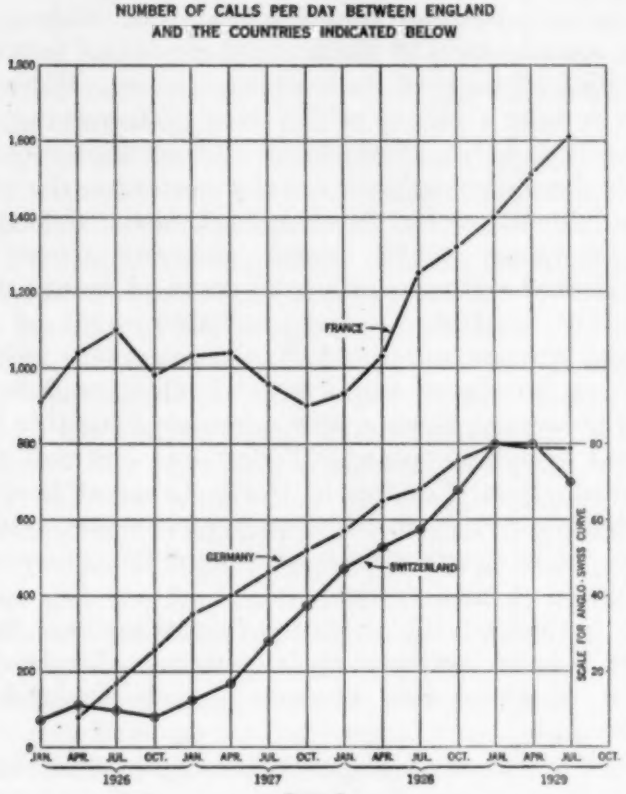


FIGURE 3

It may be said in regard to provision of plant, as distinct from questions of operation and rates that most transit countries have adopted a far-sighted policy, and have laid expensive cables freely, to provide for considerable growth of traffic passing through their territory. Indeed, the development of European international traffic witnessed during the past few years has

been in no small measure due to such international-mindedness.

Adjustments Rate

The question of rates on international calls also presents many complexities. On the one hand, transit countries might naturally be expected to measure the satisfactoriness of a rate largely in terms of the return it nets them on their investment. Terminal countries, on the other hand, while naturally having the same interest in the return, also associate with rates the question of whether or not they are giving satisfaction to their citizens who use the service. At the same time, the transit country is likely to consider, and with some misgiving, that a rate quite satisfactory from the user's point of view will in a short time create a demand for more through circuits and therefore for an increased capital investment on its own part. With finances on a normal footing no embarrassment would accrue from such growing demands, but because of post-war stringencies most of the nations of Europe have had to consider capital outlays very carefully. Such problems as these are, however, rapidly yielding to solution, and the experts who are struggling with them are of course greatly aided by the fact that the telephone business, wherever wisely administered, has always proved quite able to pay its own way.

The question of international rates also brings into consideration the varying cost indices between nations. As closely associated as they are, the various countries of Europe differ considerably in the matter of cost levels. A rate satisfactory to a country of low costs would obviously not ensure an adequate return on equivalent telephone plant in a country of high costs. Here again, however, a working agreement has been arrived at, and under its influence, together with that of a steadily increasing supply of modern circuits, international traffic is growing by leaps and bounds.

The Problem of Language

Another ever-present difficulty concerning long distance telephony in Europe is that of languages. This manifests itself in two distinct ways. One is the hindrance it interposes to those who would like to use the international telephone; the other is presented in the operation of international circuits. The language difficulty is not so great in the case of neighbouring nations such as France and England or Germany and Denmark, because in advance of the telephone, immediate geographical proximity had already spread some knowledge of each country's spoken language over the boundary into its neighbour's territory, but it becomes of no inconsiderable magnitude in the case of calls between widely separated countries, as between Sweden and Spain, or Poland and Italy, or England and Czecho-Slovakia. In the case of such countries, the citizens engaged in international business are for the most part quite unfamiliar with each other's speech and usually conduct their international business by mail or telegraph with the aid of foreign correspondence clerks, i.e. translators with special linguistic training. Considering that in such cases the general use of the telephone involves new mental equipment and a new business technique, the comparative rapidity of its growth is remarkable.

From the operating point of view also, the language separation involves special difficulties which are, in fact, far more serious than those arising from separation in space. These difficulties are minimized where through circuits between the terminal countries are available, and this we might say is the normal method of providing international telephone connections. Even so, to take specific cases, it is not very practicable to provide operators in England who can speak Spanish and Italian, and in Madrid and Rome who can speak English. In general too many languages would be involved; or to put it another way, the number of through

circuits now in existence between each pair of countries is not large enough to warrant the maintenance of groups of reserve and emergency operators, one group for each pair of languages. In the cases cited of Anglo-Spanish and Anglo-Italian circuits this difficulty is overcome by the use of French for operating, because groups of French-speaking operators are, in any case, required to work the circuits to the intermediate French-speaking countries. Similarly in the case of

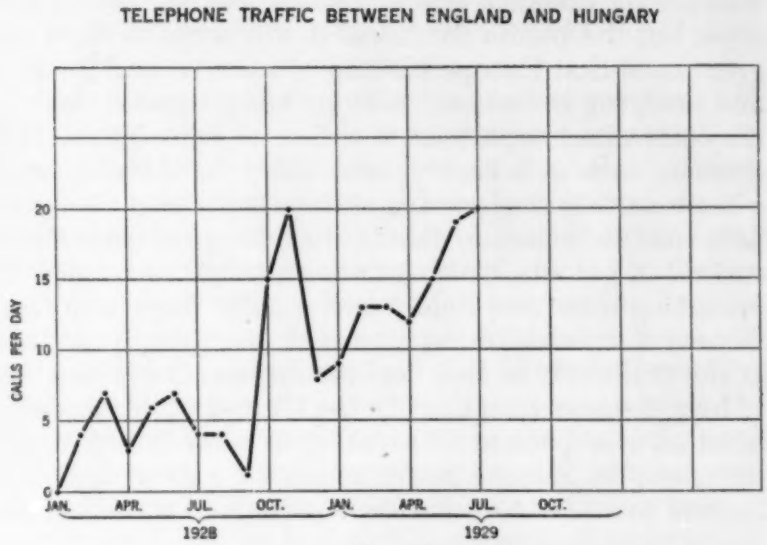


FIGURE 4

other groups of through lines, a suitable common language is employed.

In most cases where a circuit has to be built up specially for a long distance international call, the language difficulty is much aggravated. In these circumstances built-up circuits are only used in European international service in the early stages of traffic development or for the routing of emergency calls in the case of break-downs. "Through" circuits are permanently put in service between selected cities in the terminal countries as soon as the traffic is sufficient to

fill even one circuit. Transit traffic and the number of long through circuits required to handle it are rising with the general tide, as witness the record of traffic between England and Hungary as shown in Figure 4.

Telephone Systems in United States and Europe—A Contrast

The preceding paragraphs do not propose to be a complete catalog of the peculiar and unique difficulties which long distance telephony has had to face in Europe, but the points enumerated will serve to show the great need that Europe has had of some central guiding and unifying influence. Europe has possessed none of the centralized departments which we prize in the Bell System, such as a central laboratory for development, a headquarters engineering staff to study and advise on field conditions and to standardize design, a centralized control of patents, making them equally available to all operating units and finally and equally important, machinery for establishing standard operating practices. It can truthfully be said that the successful working out of long distance telephony in the United States has supplied an ever-present illustration of what international telephony in Europe might attain to, and without our success overseas to point to, the path of its advocates would have been much rockier.

However, Europe could not have achieved its rapid progress in international telephony without some very definite guiding and unifying influence. Naturally, the need of some permanent international machinery to direct the progress of international telephony has long been recognized, and doubtless would have sprung into existence years before it did had it not been for the War. Indeed, there have existed for many years such illustrative organizations as the Universal Postal Union and the International Telegraph Union, with their permanent secretariats and periodic congresses.

As has already been pointed out, international tele-

phony presents many unique difficulties. No special precision of adjustment is required for the transfer of mail, freight and passengers across national boundaries, and even the problem of international telegraphy is simple compared with that of telephony. The electric circuit which transmits a telephone message must operate as a single unit from end to end. Transmission standards as expressed by the various European nations in transmitter and receiver efficiency, in the behaviour of repeaters, in the design and spacing of loading coils, and in countless other respects, have had to be adjusted to a basis of practical equality.

In large measure the influence guiding telephony in Europe has been supplied by a voluntary organization, made up of representatives from each of the national telephone administrations. This Association, known as the International Consultative Committee for Long Distance Telephony in Europe—or C. C. I. for short—came into existence in 1924 as the outgrowth of an informal advisory committee which originated about one year earlier. It has been said that the initial meeting of the C. C. I. was perhaps the first occasion after the War when official representatives of the formerly combatant powers, other than soldiers and diplomats, met around the conference table. Whether this is true or not, it can safely be said that the meetings and conferences of the C. C. I. represent as fine an international spirit as has been manifested by any gathering of representatives of the Powers; and to this, one can scarcely refrain from adding that, by labouring on behalf of international telephone service, they have conspicuously advanced the basis of understanding between nations and the cause of permanent peace. We in the United States have always considered the telephone as an outstanding instrument of service, and it is gratifying to see it now so established in Europe that it is beginning to prove its power in this respect.

R. W. King.

1929 Convertible Bond Offer of the American Telephone and Telegraph Company

THE American Telephone and Telegraph Company offered to its 455,000 stockholders of record on May 10, 1929, $219,112,700 of Ten-Year Convertible 4½% Gold Debenture Bonds due July 1, 1939, in the proportion of $100 principal amount of bonds for each six shares then held. The bonds were offered for subscription at face value and payment in full was due July 1, 1929. The offer was not underwritten.

The principal amount of the issue, $219,112,700, represents the largest financing ever undertaken by the Bell System, and is believed to be the largest ever offered to stockholders for subscription by any corporation; the 1928 stock offer of the American Company amounting to about $185,000,000 doubtless having previously held the record. If all of the bonds should be converted into stock at $180 per share during 1930 under Option (*a*), the Company would receive an additional $175,000,000 or a grand total of nearly $400,000,000.

The purpose of the offering was to provide funds for the payment of approximately $75,000,000 Collateral Trust Four Per Cent. Bonds of the Company maturing July 1, 1929, and for new construction which is required by the Bell System to care for additional business resulting from the continuously increasing use of telephone service. In the current year more than $550,000,000 will be spent on plant additions, betterments and replacements. This is the largest program in the history of the Bell System and similar large expenditures are planned for the years to follow.

Terms of the Issue

The bonds are convertible into stock of the Company during the period January 1, 1930 to December 31, 1937 at the conversion price of not more than $180 per share for the year 1930, $190 per share for the years 1931 and 1932 and $200 per share for the remainder of the period, provided, however, that bonds called for redemption on any date within the conversion period may be surrendered for stock not later than their redemption date. The conversion prices are subject to reduction upon the issue from time to time of additional stock by the Company in accordance with the terms of the indenture. In converting, the bondholder may take (*a*) one share of stock for each $100 principal amount of bonds surrendered, on payment in cash of the difference between the conversion price then in effect and $100, or (*b*) he may take as many shares of stock as the principal amount of bonds surrendered is a multiple of the conversion price then in effect, and if there is a remainder the bondholder may take one additional share on payment in cash of the difference between the current conversion price and such remainder. When the bonds are selling at a market price above their principal amount it will usually be advantageous to the bondholder to convert under Option (*a*).

Results of the Issue

In recent months, the general investing public has shown a slackened interest in bonds except those with stock privilege features. Convertible bonds have proven quite attractive however, and this fact contributed to the marked success of the convertible bond offering of the American Company. A total of 165,000 subscriptions was received, exceeding that for any previous Bell System bond issue. In addition there were many subscriptions filed by banks and brokers for individual investors which cannot be identified as such

and are accordingly excluded from the count. Only one-half of one percent of the rights was allowed to lapse. These are satisfactory results, especially when it is considered that of the 455,000 stockholders entitled to subscribe, relatively few had had previous experience with convertible bond offers.

Due to the changing conditions in the securities market, which had their effect on American Telephone stock and thus on the rights, the price of the latter exhibited rather marked variations during the subscription period. The day of the announcement of the issue, April 30, rights sold as high as $\$7\frac{7}{8}$. During May the general price trend was downward and a low of $3 was reached on several days at the end of the month. June witnessed a reversal in trend, the price rising to a high of $8 on June 29, with a final price on the New York Stock Exchange of $\$7\frac{7}{8}$.

As has always been the case when the American Company offers securities to stockholders, the bulk of the subscription payments is received at the very end of the period. Banks and brokers especially, making payment for their own and for their clients' accounts, observe this practice in order to save interest. Of a total of $218,000,000 received, only $35,000,000 had reached the Company and been deposited by June 27, four days before the expiration date. On July 1 alone, over $106,000,000 was received and deposited.

To add to that day's volume of business the Treasurer's Office issued checks for $60,000,000 in payment of Collateral Trust Four Per Cent. Bonds maturing then and presented on or before July 1 and also $2,730,000 in payment of bond coupons due July 1. That part of the proceeds of the convertible bonds not required for immediate use was invested in short term securities of unquestionable safety, principally government and municipal obligations.

A résumé of the results of the bond issue is set forth in the following table:

TABLE I

STATISTICS ON THE 1929 CONVERTIBLE BOND ISSUE

Principal amount of bonds offered	$219,112,700
Approximate amount of bonds subscribed	$218,000,000
Percent subscribed	99½%
Number of stockholders of record	455,160
Approximate number of subscriptions	165,000
Subscriptions in percent of stockholders	36%
Average principal amount offered, per stockholder	$481
Average principal amount per subscription	$1,314

AID GIVEN STOCKHOLDERS

In accordance with the Company's policy of endeavoring to offer special assistance to those of its stockholders who seemed most likely to require it, individually addressed letters were sent on May 22 to 8,000 individuals entitled to subscribe who had failed to exercise their rights to the 1928 stock issue. The communication explained that the 1929 rights had value and that they should either be used in subscription or be sold for cash by July 1. These stockholders had, of course, already been sent the circular of April 30 announcing and giving full details of the terms of the offer and also the circular of the Bell Telephone Securities Company which accompanied the warrants mailed on May 20 to all stockholders. The latter communication included a list of simplified questions and answers about the issue and an order form to facilitate the purchase or sale of rights through the Bell Telephone Securities Company.

As in the case of the 1928 stock issue, the Associated Companies were furnished with the names and addresses of those of the 8,000 stockholders who lived in their territory, and attempts were made to reach these individuals personally before the close of the subscription period. In cases where a telephone communication was insufficient, a fuller explanation was given in a personal interview by a Company representative. These stockholders were, with few exceptions, of limited means and the ones who could least afford to sacrifice the value of their rights.

Through these varied means, the interests of thousands of stockholders were protected, and as had been the previous experience, many of them expressed their appreciation for the assistance received.

Other Assistance Rendered

Over 385,000 stockholders or 85 percent of the total stock list received fractional warrants, some with and some without full warrants, and all of these fractional warrants had to be pieced out in order that they might be utilized in subscription, or which could be sold. In order to facilitate these transactions for the stockholders residing in all parts of the country, the Bell Telephone Securities Company as in the past offered its facilities for the purchase or sale of rights and the filing of subscriptions both at its home office and through most of the business offices of the Associated Companies.

Transactions in rights in the field averaged about 7½ rights, while subscriptions filed averaged about $425. An idea of the extent to which these facilities were utilized may be gained by the fact that of a total of 154,000 transactions for the purchase and sale of rights effected through the Securities Company, 103,000 were handled through the field. The latter figure compares with about 76,000 transactions so handled in the field during the 1928 stock issue and represents more than a one-third increase in activity. In addition over 31,000 completed subscription transactions were handled through the Associated Companies. The stockholders in the western states, as was the case last year, were the ones who availed themselves most largely of the facilities offered through the Associated Companies.

The following table gives data on rights purchases and sales and subscriptions filed through the Associated Companies rendering aid during the bond issue.

1. A view of the Communications Bureau with the Mail Section and Rights Bureau in the background.

2. A portion of the Subscription Reviewing and Recording Sections with the Bond Issue Cash Bureau in the foreground.

3. A UNIT OF THE BOND DELIVERY SECTION METERING REGISTERED MAIL ENVELOPES PREPARATORY TO MAILING.

4. A SECTION OF THE BOND DELIVERY ORGANIZATION SHOWING EMPLOYEES ENGAGED IN COUNTING BONDS, RECORDING THE ALLOTMENT TO INDIVIDUAL SUBSCRIBERS AND ENCLOSING THE BONDS IN ENVELOPES.

5. A VIEW OF THE MAILING UNIT OF THE BOND DELIVERY ORGANIZATION SHOWING REGISTERED MAIL ENVELOPES BEING PREPARED AND CHECKED PRIOR TO DELIVERY TO THE POST OFFICE.

TABLE II

1929 BOND ISSUE TRANSACTIONS HANDLED LOCALLY BY ASSOCIATED COMPANIES FOR THEIR PATRONS

Associated Companies	Purchases and Sales of Rights		Subscriptions Filed	
	Number of Transactions	In Percent of Stockholders Resident in the Territory	Number of Transactions	In Percent of Stockholders Resident in the Territory
New England Tel. & Tel. Co.	3,072	3.0	1,106	1.1
Southern New England Tel. Co.	800	5.7	165	1.2
New York Tel. Co.	12,011	14.2	3,629	4.3
New Jersey Bell Tel. Co.	3,188	12.2	818	3.1
Bell Tel. Co. of Penn.	11,642	27.3	3,365	7.9
Chesapeake and Potomac Tel. Co.	5,112	27.6	1,366	7.4
Southern Bell Tel. & Tel. Co.	4,119	25.3	971	6.0
Michigan Bell Tel. Co.	3,039	43.9	622	9.0
Indiana Bell Tel. Co.	960	38.8	135	5.5
Wisconsin Tel. Co.	4,156	49.9	1,208	14.5
Illinois Bell Tel. Co.	15,234	34.9	4,607	10.6
Northwestern Bell Tel. Co.	5,891	49.3	1,566	13.1
Southwestern Bell Tel. Co.	11,892	55.8	3,363	15.8
Mountain States Tel. & Tel. Co.	4,290	45.6	1,358	14.4
Pacific Tel. & Tel. Co.	17,541	48.6	7,491	20.8
Total	102,947	23.1	31,770	7.1

Thus in all parts of the country the Bell System facilities aided stockholders, and especially small stockholders, in handling their rights. In addition through the New York and Boston offices of the American Company, the Securities Company handled a total of 51,000 transactions in rights as against 45,000 of such transactions in 1928, the majority of these being handled by mail. These transactions averaged in size 8⅓ rights.

ORGANIZATION AND PERSONNEL

As is the case of stock offers, this convertible bond issue was handled by the Treasury Department. Although its permanent personnel is experienced in conducting stock issues, there were many problems of a different nature to solve, as for example, that of pro-

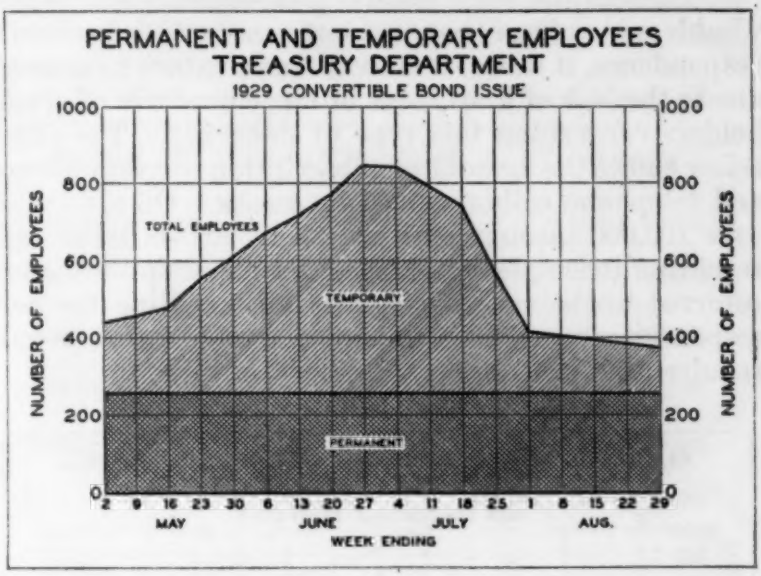
duction in various phases of the work, the estimation of personnel requirements and the handling and delivery of bearer securities. Stock issue methods were used as much as possible, but there were some operations for which no recent precedent existed and which required the development of entirely new practices.

The bonds were issued in the form of temporary bearer certificates with the first two semi-annual interest coupons attached, these temporary bonds being exchangeable on and after October 1, 1930 for the definitive bonds with all subsequent coupons attached. This plan of issuance was decided upon as more practical and economical than that of issuing temporary interim receipts and then, prior to the date of the first interest payment, exchanging them for the engraved bonds with all coupons attached. As it seemed probable in the light of past experience that numbers of bondholders would convert their bonds before October 1, 1930, the number of pieces of the definitive bonds to be produced, authenticated and exchanged should be substantially reduced and the saving to the Company effected by this plan should be of substantial size.

To assist the permanent employees of the Treasury Department in handling the bond issue work, a force of about 600 temporary employees was utilized, this peak being reached, of course, near the close of the subscription period. The number of temporary employees in the 1928 stock issue, however, exceeded this total by about 125.

The quality of the temporary personnel was high. Although the bond issue began during a period when it was not possible to obtain as high a percentage of men from the colleges at the beginning of the issue as was done last year, nevertheless, as time passed and more students, recent graduates, and instructors became free for summer employment, numbers of them were added to the organization. A total of 189 men from 76 colleges and universities were engaged. These

men were of the type which proved very adaptable to their new conditions. In addition, more than a score of permanent employees from other parts of the Bell System filled positions of responsibility.

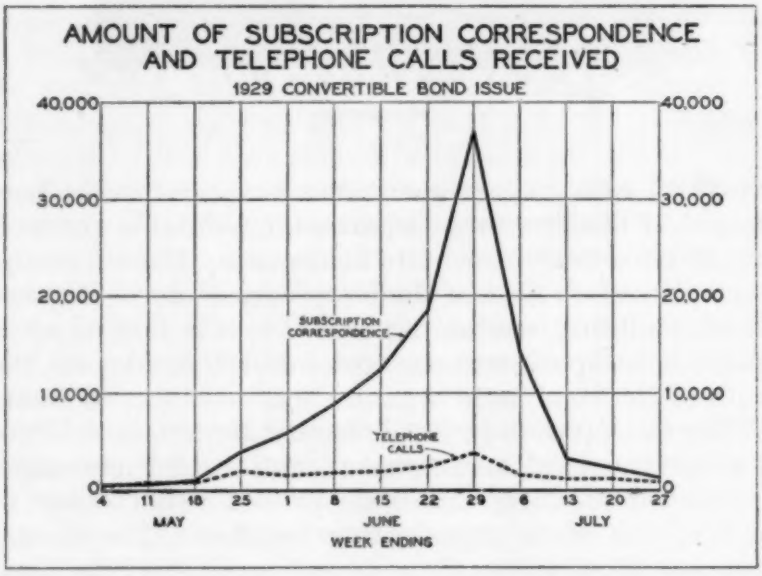


With such an increase in the work and in the personnel of the Treasury Department, available quarters at 195 Broadway were quite inadequate. Consequently, the entire sixth floor of the New York Federal Reserve Bank Building, containing 33,000 square feet of additional office space, was engaged, and 560 employees, the bulk of the bond issue organization, were moved there. While this division in the Treasury Department forces was not an ideal arrangement, automobile messenger service at frequent intervals proved satisfactory in linking the whole organization together. The accompanying illustrations show various sections of the bond issue organization in the process of handling their work.

The data on the volume of mail give one an idea of the size of the undertaking. About a million and a quarter pieces of bond issue mail were sent and received,

and at the same time, of course, the regular Treasury Department correspondence was handled, and the regular July dividend checks to over 455,000 stockholders were prepared for release.

Although the bond issue correspondence was somewhat less in volume than was last year's stock issue correspondence, it was of a more difficult nature to answer, due to the lack of knowledge of large numbers of stockholders concerning this type of financing. The chart below shows the amount of subscription correspondence and telephone calls received by weeks. Of a total of over 100,000 incoming letters, about 35,000, those representing incomplete and irregular subscriptions, were referred to the special organization handling the correspondence work. Of the latter total almost one-half required the preparation of special replies.



As indicated by the chart on the next page, the subscriptions did not flow in evenly over the entire period but rose to a sharp peak at the close. For example, the

number of subscriptions received through the middle of June represented less than one-sixth of the ultimate total. The work involved in correspondence and in the rights purchase and sale transactions also, experienced marked peak loads, and on July 1 the operation of delivering the temporary bonds to the subscribers began.

This problem of delivering the bonds was one of the most important confronting the Treasury Department on which no help could be had from past stock issue experience. In order to fill the subscription allotments 307,600 $100 pieces, 39,700 $500 pieces, and 167,350 $1,000 pieces, or a total of 514,650 pieces were required. When it is considered that these bonds are in bearer form, an idea may be gained of the great responsibility placed upon each employee engaged in bond delivery work. It is a credit to all concerned that these bonds went through all the necessary steps of the routine from receipt at the vaults to delivery to the post office with-

out the loss so far as is now known of a single piece by the Treasury organization.

Needless to say, in order to achieve this result, extreme care and frequent verifications were necessary. The bonds were delivered to the main vault, located not far from the 195 Broadway offices, where complete count was made by designated officials. Great care was exercised in their subsequent transfer to the secondary vaults for counter delivery at 195 Broadway, and for the mailing unit located in the Federal Reserve Bank Building. Upon their receipt there and again prior to their dispatch to subscribers either by mail or by delivery at the counter, additional verifications were effected. In mailing, special precautions were taken in order that the bonds be allotted in the correct amount and in the correct denominations. To insure such accuracy each subscription was handled by two persons: the first man counting the bonds and recording the allotments to the individual subscribers, and the second man verifying the allotments and enclosing the bonds in envelopes. After final verification, the 130,000 specially manufactured envelopes needed for mailing the bonds had to be sealed by hand, an operation which required fifty gallons of mucilage.

The affixing of the postage to such a quantity of registered mail was accomplished in a unique and unusually efficient manner through the use of newly developed postage meter machines. These machines, which were the first of their kind to be put in practical operation, were specially adapted for the use of the American Company on this work, being so adjustable as to imprint on the envelopes varying amounts of registered postage according to the different weights of the individual pieces of mail involved. Besides being speedier than the old method of affixing stamps by hand, these machines eliminated the problem of maintaining a supply of registered mail stamps in varying amounts and accounting for their use, since the meters attached

to the machines automatically recorded this. In all, over $24,000 meter postage was imprinted.

The convertible bond issue, the largest piece of Bell System financing, was in all respects a success. The financial press spoke well of the issue, a substantial interest was manifested by bankers and brokers, and a wide-spread distribution of the bonds was obtained which has broadened the investment interest in the business. The stockholders were aware or were made aware of the value of their rights to such an extent that only a negligible percentage was allowed to lapse, and many pleasant public relations contacts were established in all parts of the country through Bell System employees. Sincere appreciation is due these employees, both permanent and temporary, who contributed to the success of the issue by their loyal and effective work.

H. Blair-Smith

Listening Device Aids in Combating the Fruit Fly Pest in Florida

EDITOR'S NOTE: *Surveying every field of scientific endeavor to find means to combat the ravages of the Mediterranean fruit fly, it occurred to the entomologists of the Bureau of Plant Industry, U. S. Department of Agriculture, that the presence of the larvae within the fruit might be detected by a sensitive electrical stethoscope.*

Dr. David Fairchild of the Department of Agriculture asked President W. S. Gifford of the American Telephone and Telegraph Company for assistance in the very urgent problem at hand. A deputation from the Technical Staff of the Bell Telephone Laboratories, with appropriate apparatus, was promptly sent to Florida.

The story of the application of telephone research to the study of a problem in nowise connected with communication is told by Mr. D. G. Blattner who was in charge of the work.

THE business of being a telephone engineer sometimes leads to unusual experiences far afield of the telephone business. Such experiences usually result from the interest shown by the Bell System in the problems of the public, and from the intense interest on the part of the public in the many communicational developments that are going on about us. It was, therefore, not surprising that when the government entomologists discovered the presence of the dreaded Mediterranean fly in the Florida citrus fruit district that they should have called upon the Bell System for assistance.

The Mediterranean fruit fly was first observed in fruit from the Azores about a hundred years ago and

since that time the growing of fruits that serve as hosts to the pest has been seriously handicapped the world over except in continental United States. The discovery of the pest in the United States might, therefore, be reasonably expected to cause alarm. Moreover, when it is recalled that the list of fruits that serve the fly as hosts is a long one, including practically all of our common fruits, and many of our vegetables, it is no wonder that every possible facility for combating the pest should have been resorted to.

The Mediterranean fruit fly is similar in size and general appearance to the common house fly except for its markings, its general adaptability to its own particular purposes, and its vastly greater hardiness. In appearance it has a series of brownish yellow stripes across the body and wings, and altogether, might be considered as rather chic. As to its adaptability and hardiness, it appears that the female is able to deposit her eggs at just the proper depth below the fruit rind regardless of the thickness of the rind and while the fly cannot withstand freezing temperatures, it appears to be able to stand temperatures about as low as the fruit that it attacks. As for its likes and dislikes, it appears to have no difficulty in choosing the fruit most to its liking and while as a larva it appears to have well defined ideas about how a respectable larva should pupate, it can and will adapt itself to almost any condition which may be imposed upon it. The whole life cycle of the fly may take place within a period of from two weeks to six months, depending upon the conditions, and one fly has been known to lay as many as 800 eggs. If it is assumed that for such favorable conditions as exist in Florida the complete life cycle takes place in a month, and that the fly as such lives to an age of four months and produces an average of 400 eggs, half of which hatch out to be females, a single fly might produce a horde of about 35,000,000,000 members in a period of six months except for deaths in the family from time

to time. In other words, if every person in the United States were to eat an orange a day, it would require a year for the present population to consume as many as this one fly and her offspring might destroy in six months from the date of her maturity.

The destruction of the fruit by the Mediterranean fly is accomplished during the larva stage of development. Because of its " Volsteadian " sentiments, the larva, unlike many other larva, completely riddles the fruit in its efforts to keep in advance of the fermentation of the fruit juice that accumulates about it. To enable it to make rapid progress in its burrowing it is equipped with two spine-like hooks with which it tears the tissue. It occurred to the entomologists on the job that perhaps the Bell System might be able to provide apparatus by means of which the tearing of the fruit tissue might be detected. The situation was brought to the attention of President Walter S. Gifford of the American Telephone and Telegraph Company by Dr. David Fairchild of the United States Department of Agriculture and the present writer with one of his associates were dispatched from the Bell Telephone Laboratories to Orlando to see what might be done.

In consideration of the problem it seemed reasonable to expect that the larvæ might expend energy in the fruit in any of the following forms:

1. Acoustic effects from the larva direct.
2. Heat liberated as a result of the activity of the larva.
3. Muscular electrification of the larva.
4. Mechanical vibration of the fruit tissue caused by the larva.

Of these, the first two forms were considered to be unimportant as a telltale of the presence of the larvæ. The sound generated, as heard in the fruit, would probably be very limited in amount and the fruit structure is not a good sound transmitting medium while the heat generated would be so small in amount and the thermal

capacity of the fruit so large, that the temperature change would probably be negligibly small. As for electrification, it would seem that the chances of success would be reasonably good when it is recalled that the electrification of some of the smaller muscles of the human eye is of the order of several microvolts. In regard to vibrational energy it would seem that a reasonable amount of vibration might be produced and that it would be transmitted throughout the whole structure of the fruit with reasonable facility. Further it would be expected that the character of the vibrations would be determined by the fruit structure rather than by the maggot so that the sounds would not vary with the size of the maggot. Because of these considerations, it appeared that our chances of success would be best if our efforts were directed along the lines of the electrification and the vibration effects.

As for apparatus that might be used in detecting vibrational effects, we were in a rather happy position. The electrical stethoscope, an instrument developed a few years ago to aid in the instruction and training of student physicians and to assist older physicians whose hearing has become somewhat impaired, seemed to be admirably suited for this particular problem. It was planned that a fruit suspected of being infested would be placed upon the stethoscope transmitter supported on a vibrationless support, that the amplifier would be turned on and such of the filters in the stethoscope as might seem most suitable would be switched in to exclude extraneous noises. The results would be observed by listening to a telephone receiver. In case the maggot sounds could not be heard at the surface of the fruit it was planned to replace the stethoscope transmitter by a special electro-mechanical reproducer used in theatre sound-reproducing systems and designed with a long needle which might be inserted well into the fruit. Also laboratory work involving the use of an amplifier designed to give particularly low tube-noise

and very great sensitivity was temporarily suspended in order that we might have this device to use in case the stethoscope amplifier was found to be unsatisfactory.[1]

Upon arrival in Orlando, we found that the entomological forces had been highly organized for action, that the national guard had been called out to aid in carrying out the rather extreme measures that had been decided upon, and that having an infested fruit in one's possession was considered a grave offense. In spite of these difficulties, however, we succeeded in getting a few pieces of fruit that were thought to be infested and the battle was on. Out of the first four such fruits, three were found to be "noisy" and the fourth one was "quiet." After demonstrating the sounds to the various entomologists on the job, two of the "noisy" fruits were opened and found to contain active larvæ while the "quiet" one was found to contain none.

Having thus shown the possibility of hearing the larvæ inside the fruit, the question was raised as to how the detecting apparatus might be used to best advantage. It was obvious from the start that as a means of inspection of fruit for market, it would not be satisfactory because of the time and expense involved. It was found that the larvæ were more active at certain times of the day than at others and that during the active periods they work more or less intermittently. Testing of fruit would, therefore, have to be done only at certain times and if the test lasted only a moment there would be no assurance that the larvæ might not be resting at that particular moment. The listening apparatus appeared to offer the greatest possibility of service, rather, as a means of carrying on certain researches. At the present time, means for controlling or eliminating the pest are being worked out on the basis of submitting a fruit to the ravages of the pest for a limited time, after which it is opened for observation.

[1] Test data indicate that the larva produces vibrations at the surface of the fruit of the order of a hundredth of a millionth of a centimeter.

The difficulty with such a method is that each individual test is necessarily terminated after the first observation. By means of the listening apparatus, it would be possible to continue the test on each particular sample for such duration of time as might seem desirable.

D. G. BLATTNER.

Abstracts of Technical Papers from Bell System Sources

Reciprocal Theorems in Radio Communication,[1] by John R. Carson. Two reciprocal theorems, the generalized Rayleigh theorem and the Sommerfeld-Pfrang theorem, are of great theoretical importance in radio communication. A careful analysis of these theorems and their mathematical derivations shows that they are quite distinct and their practical fields of application different. In particular it shows that the Sommerfeld-Pfrang theorem labors under restricions, implicit in its mathematical derivation, which seriously limit its field of practical applicability.

Telephone Circuits for Program Transmission,[2] by F. A. Cowan. Systems of telephone circuits which are extensively used in the transmission of programs to broadcasting stations are described in this paper. Certain stages in the development of these systems are considered and the general requirements for satisfactory transmission at the present time are enumerated. The arrangements of the systems as well as the procedures used in setting up and maintaining them are discussed.

Correlation of Directional Observations of Atmospherics with Weather Phenomena,[3] by S. W. Dean. This paper analyzes some data on the direction of arrival of static at Houlton, Maine, obtained by means of a recorder and a cathode ray radio direction finder; and points out that in certain cases there is a relation between the direction of static and the location of storm

[1] Proceedings of the Institute of Radio Engineers, Vol. 10, June, 1929, pp. 952–956.

[2] A. I. E. E. Journal, July, 1929, pp. 538–542 (abridgment).

[3] Proceedings of the Institute of Radio Engineers, Vol. 17, July, 1929, pp. 1185–1191.

centers. Two cases are discussed in which day by day bearings showed static sources in the direction of moving storm centers.

A Direct-Current Amplifier for Measuring Small Currents,[4] by J. M. Eglin. A direct-current amplifier consisting essentially of a Wheatstone bridge, having the amplifying tube in one arm and a balancing tube in another, has been described by P. I. Wold and by C. E. Wynn-Williams. This circuit has now been developed to give a constant amplification for currents in either direction up to 10,000 times the lowest measurable value. The amplification and the lowest measurable current are alterable together by changing the resistance introduced between the grid and filament of the amplifying tube. With tubes of high insulation, the amplification can be made as large as 10^6; and the measurable current as low as 10^{-14} ampere. Some improvements of the circuit are: (1) the insertion of a resistance in series with the tube in one arm of the bridge to " compensate " for variations in plate and grid battery voltages; (2) the suspension of the tubes to protect them from mechanical vibrations; (3) the use of tubes with pure tungsten filaments to avoid changes in contact potentials, and with plates enclosing the filaments completely to lower the effects of wall charges. In a " null " method of using the circuit the values of the grid resistance and an auxiliary potential introduced in the grid-filament circuit are sufficient to determine the measured current.

Meeting Long Distance Telephone Problems,[5] by H. R. Fritz and H. P. Lawther, Jr. There have been written many papers describing various technical and apparatus developments of value in providing long distance telephone service. Several papers have also appeared covering specific transmission or operating

[4] Journal of the Optical Society of America and Review of Scientific Instruments, Vol. 18, May, 1929, pp. 393–402.

[5] A. I. E. E. Journal, July, 1929, pp. 547–550 (abridgment).

problems, or dealing with the advance planning of the telephone plant. Feeling that it might be of interest, particularly to the young engineering graduates, the writers have prepared this overall sketch of the general problem of actually providing, year by year, the extensions and additions to a comprehensive network of communication channels necessary to keep pace with a growing public demand for long distance service. Since the writers are most familiar with the area served by the Southwestern Bell Telephone Company, the discussion is restricted to that territory.

Some Measurements on the Directional Distribution of Static,[6] by A. E. Harper. The utility of directional data on static is shown, and two types of apparatus devised for such a directional investigation are compared. It is shown that a method which gives the direction of individual crashes is superior to integrating methods. The distribution of thunderstorms over the world is discussed, and comparisons are drawn between this distribution and the observed directional distribution of static. Probable geographical locations are assigned to the sources, based upon thunderstorm data and directional observations.

Maximum Excursion of the Photoelectric Long Wave Limit of the Alkali Metals,[7] by Herbert E. Ives and A. R. Olpin. Earlier experiments have shown that the long wave limit of photoelectric action in the case of thin films of the alkali metals varies with the thickness of the film. A maximum value is attained greater than that for the metal in bulk, which for the majority of the alkali metals lies in the infra-red. The wavelength of the maximum excursion of the long wave limit was first studied for Na, K, Rb and Cs. In each case it was found to coincide with the first line of the prin-

[6] Proceedings of the Institute of Radio Engineers, Vol. 17, July, 1929, pp. 1214–1224.

[7] Physical Review, Vol. 34, July 1, 1929, pp. 117–128.

cipal series, i.e., the resonance potential. If this relation holds for lithium, its maximum long wave limit should be greater than that of sodium. This was tested and confirmed by experiments in which red-sensitive lithium films were prepared, sensitive to 0.6708 μ. It is suggested that photoelectric emission is caused when sufficient energy is given to the atom, to produce its first stage of excitation. The identity of photoelectric and thermionic work functions suggests that atomic excitation is the initial process in thermionic emission as well.

Magnetic Testing Furnace for Toroidal Cores,[8] by G. A. Kelsall. When making magnetic tests at high temperatures trouble is often experienced in maintaining the insulation between turns of the magnetizing and exploring windings and between the windings and the test sample.

This paper describes a magnetic testing furnace for toroidal specimens which eliminate these difficulties. By means of this furnace the test sample may be passed through a definite temperature cycle and the variation in magnetization for a constant magnetizing force determined or the temperature may be held constant while measurements are made for the B-H curve or for a hysteresis loop.

Electrical Wave Analyzers for Power and Telephone Systems,[9] by R. G. McCurdy and P. W. Blye. This paper describes two types of electrical analyzers which have been developed for the direct measurement of harmonic components of voltage and current on power and telephone systems. These devices are assembled mechanically in a form suitable for use either in the laboratory or in the field. Both instruments, which differ chiefly with respect to sensitivity and input circuit arrangement, employ multistage vacuum

[8] Journal of the Optical Society of America and Review of Scientific Instruments, Vol. 19, July, 1929, pp. 47–49.
[9] A. I. E. E. Journal, Vol. 48, June, 1929, pp. 461–464 (abridgment).

tube amplifiers and two duplicate interstage selective circuits.

The power circuit analyzer is designed to measure harmonic voltages in the frequency range from 75 to 3000 cycles and over a voltage range from 0.5 millivolt to 50 volts. The telephone circuit analyzer operates over the same frequency range and measures harmonic currents as low as 0.05 microampere and voltages as small as 0.005 millivolt. Both analyzers are adapted to measure small harmonic voltages and currents in the presence of the fundamental component and other harmonics relatively large in magnitude.

A number of devices are described which have been adopted for eliminating various sources of error. The paper presents in detail the characteristics of both instruments with respect to selectivity, sensitivity, linearity, balance of input with respect to ground, generation of harmonics, and susceptiveness to stray fields.

Solution to a Problem in Diffusion in Employing a Non-Orthogonal Sine Series,[10] by R. L. Peek, Jr. In this paper are described some recent developments in to diffusion through a membrane between a chamber in which a constant pressure of the diffusing material is maintained and a second closed chamber, initially evacuated, into which the material diffuses. Assuming Fick's law to apply, a solution is obtained in the form of an infinite series of a type similar to those applying to other problems in diffusion. The sine series to which the solution reduces at zero time is non-orthogonal, but it is shown that by a modification of Fourier's method the coefficients of the terms may be directly determined. There is included a proof of the convergence of the series considered.

Recent Developments in Telephone Construction Practices,[11] by B. S. Wagner and A. C. Burroway. In this paper are described some recent developments in

[10] Annals of Math., 2d Series, Vol. 30, April, 1929, pp. 265–269.
[11] A. I. E. E. Journal, Vol. 48, May, 1929, pp. 366–369 (abridgment).

telephone cable installation and maintenance practices. The paper is divided into three sections: (1) Gas pressure testing for detecting and locating sheath defects before they result in failure. (2) Methods for reducing bowing and other movements of cable which in time cause fracture of the sheath. (3) Catenary construction for long spans, such as at river crossings.

A Method of Sampling Inspection,[12] by H. F. Dodge and H. G. Romig. This paper outlines some of the general considerations which must be taken into account in setting up any practical sampling inspection plan. An economical method of inspection is developed in detail for the case where the purpose of the inspection is to determine the acceptability of discrete lots of a product submitted by a producer. By employing probability theory, the method places a definite barrier in the path of material of defective quality and gives this protection to the consumer with a minimum of inspection expense.

Statistical Theories of Matter, Radiation and Electricity,[13] by Karl K. Darrow. In this paper is discussed the atomic or kinetic theory of gases which has ranked for over half a century as one of the triumphs of theoretical physics. Owing to brilliant new work in the fundamentals of statistical theory, a competent kinetic theory of radiation and of electricity in metals now exists beside its predecessor, and perhaps even includes it.

Articulation Testing Methods,[14] by H. Fletcher and J. C. Steinberg. This paper is chiefly concerned with the technique of making articulation tests. The construction of a syllabic testing list, the selection of a testing crew, the methods of comparing articulation data for various crews, and the significance of the test as a measure of the speech capabilities of a system are

[12] Bell System Technical Journal, October, 1929.
[13] Physical Review Supplement, Vol. 1, July, 1929, pp. 90–155.
[14] Bell System Technical Journal, October, 1929.

discussed. Various types of lists for different uses are also discussed.

The Frequency Distribution of the Unknown Mean of a Sampled Universe,[15] by E. C. Molina and R. I. Wilkinson. In this paper the mathematical analysis is based on the Laplacian Bayes Theorem which implicitly comprehends the results of a sample together with the a priori knowledge available concerning the parameters of the universe.

The discussion is limited to a universe assumed to be normal but whose mean and precision constant are unknown. Several simplifying, yet quite reasonable, assumptions regarding the forms and independence of the a priori frequency distribution of the true mean and standard deviation are incorporated in the analysis so that numerical answers may more easily be deduced.

Conclusions, properly drawn, are usually quite definitely dependent upon the a priori assumptions made, and especially so in the case of small samples. A considerable space is, therefore, devoted to the solution of a problem in which the sample is only five, taking up a wide variety of these a priori assumptions. They give, in consequence, a wide range of numerical results, appearing in the form of probable errors in the mean of the sample. Each set of assumptions is briefly discussed indicating how the sampling technician may be able to make a selection consistent with his a priori knowledge of a particular problem.

Telephone Transmission Networks.[16] *Types and Problems of Design,* by T. E. Shea and C. E. Lane. In this paper a brief résumé of the nature of telephonic signals is given, showing how the qualities of wave composition which distinguish signals from other electrical waves set the requirements on networks and provide a basis for their design.

[15] Bell System Technical Journal, October, 1929.

[16] Presented at the Regional Meeting of the South West District No. 7, of the A. I. E. E., Dallas, Texas, May 7–9, 1929. Abridgment in A. I. E. E. Jour., Aug., 1929.

The principal functions of wave filters, equalizers, telephone transformers, line balancing networks, and artificial lines are outlined. In order that these networks may be used in conjunction with other apparatus in the telephone system they must provide efficient transmission, low distortion, good impedance balance, stoppage of longitudinal currents, stable characteristics with current variations, low external coupling, and low reflection coefficient. In addition to these requirements the network must not cross-talk into associated circuits and must have desirable impedance characteristics in the attenuation range of frequencies as well as throughout the transmission range.

An illustration of the use of transmission networks in a typical three-channel carrier telephone system is given describing the functions of the line filter sets, the directional filter sets, band filters, and equalizers.

Some of the engineering limitations on the design and construction of networks are discussed.

Speech Power and its Measurement,[17] by L. J. Sivian. This paper is chiefly concerned with the important speech power quantities—frequency spectra, distributions of instantaneous, average, syllabic and peak amplitudes, etc.—as they obtain in actual speech for a large range of voices, talking levels, and subject matters. The analysis is not nearly so complete nor so fine-grained as that which, in principle, can be derived from oscillographic records of individual speech sounds. Its advantage is in the speed with which data can be secured, under widely varying conditions and on a scale which warrants statistical conclusions. Some of the methods in use for measurements of this type are described. A " level analyzer " has been developed, primarily for the measurement of average and peak pressure amplitudes in speech and music, both as to magnitude and as to position in the frequency spec-

[17] Bell System Technical Journal, October, 1929. Presented before Acoustical Society of America, May 11, 1929.

trum. Illustrative results are given for samples of speech, music and noise.

Physical Properties and Methods of Test for Some Sheet Non-Ferrous Metals,[18] by J. R. Townsend and W. A. Straw. This paper covers an investigation which was undertaken to secure a simple and reliable method of test for sheet non-ferrous metals. An account of the early development work leading to the adoption of the Rockwell hardness tester for a preliminary inspection of sheet metals and the tensile test as the basic test to be referred to in case the Rockwell test results were near to or outside the established Rockwell limits for a given lot of material was published in 1927. The continuation of this work including establishment of test limits for four grades of brass and for two grades each of nickel silver and phosphor bronze will be published this year. This present paper describes the development work reported by these two papers.

Considerable attention has been given to the Rockwell tester, which, as a result of this work, has been found satisfactory for use as a specification instrument for brasses 0.020 in. and thicker, when used under standardized methods of test and calibrated with standard test blocks. Other tests such as the bend test, ductility test and other hardness tests have been studied but further development work is necessary.

The Rockwell hardness and tensile strength limits are given for four alloys of brass, and two alloys each of nickel silver and phosphor bronze. The physical properties of the rolling series upon which these limits were based are presented as well as experience data obtained on shipments of commercial material. The limits for brass alloys A, B and E are considered final, but the limits for the other metals are tentative until more complete experience is available.

Grain size limits are given for annealed brass and nickel silver sheet. For inspection purposes the grain

[18] Bell System Technical Journal, October, 1929.

size is estimated by comparison with the standard photomicrographs reproduced in the 1929 report of Committee E4 of the A. S. T. M. on Metallography.

Refinements in the calibration of the Rockwell tester are given, as well as the development of testing technique. An experimental model of a motor-driven bend test machine is described.

Asymptotic Dipole Radiation Formula,[19] by W. Howard Wise. In this paper the asymptotic dipole radiation formulas given by Weyl, the Reciprocal Theorem and Strutt are obtained by refining Sommerfeld's analysis.

[19] Bell System Technical Journal, October, 1929.

Notes on Recent Occurrences

TELEVISION IN COLORS

A SCORE or more of New York newspaper men, gathered in the Bell Laboratories on June 27, witnessed the first public demonstration of color television —the transmission and reproduction by electricity of moving objects in their natural colors. Through the television apparatus they saw a fluttering red, white and blue American flag; a child's playball; bright with orange, green and red; a bouquet of roses; a slice of watermelon; and—as a sort of a finale—a young woman, clad in a costume that suggested a Hallowe'en party, who smiled while she toyed with a string of red coral beads.

Television in color is an American achievement. It is the accomplishment of the same group of Bell System engineers, headed by H. E. Ives, who gave the first public demonstration of successful single-color television, about two years ago. A second step in the Bell System's development of television was accomplished last summer, when scenes illuminated by ordinary sunlight were successfully transmitted.

Much of the apparatus employed in color television is essentially the same as that used in the one-color demonstration of April, 1927. The only new features of the apparatus are the type and arrangements of the photo-electric cells at the transmitting end, and the type and arrangements of the neon and argon tubes at the receiving end.

Cells That Can "See" Colors

The photo-electric cells used in monochromatic television were sensitive only to the blue-green end of the spectrum and were, so to speak, "color blind" as to red

values. A new type of cell, using sodium in place of potassium, has been developed, and has proved responsive to all of the colors of the visible spectrum, including the deep reds. In combination with the scanning apparatus, these cells perform the function of "looking at" the scene or object to be transmitted and for this reason are sometimes referred to as "electric eyes."

So far as the eye is concerned, any color may be represented by the proper combination of just three fundamental colors—red, green and blue. The first problem in the development of color television was, therefore, that of arranging sets of photo-electric cells in such a manner that one set would be responsive to the red values, another to the greens, and a third for the blues. This has been accomplished by the use of color filters made up of sheets of colored gelatin. Three sets of cells, each with its appropriate filters, are employed and three series of television signals are generated, instead of one as in the case of monochromatic television. Three channels are used for the transmission of these signals, one for each fundamental color.

Neon and Argon Lamps

At the receiving end, three lamps are used, one for each fundamental color. The red-glowing lamp is filled with neon gas and is essentially similar to those previously used in one-color television. The sources of green and blue lights are argon tubes. In order to combine the light of the three lamps, so that they may be viewed through the scanning disc as if coming from the same point, two semi-transparent mirrors are interposed between them and the disc.

Behind the scanning disc, in addition to the lamps and mirrors, is a lens system which focuses the light into a small aperture at the front of the apparatus. The observer looking into the aperture receives, through each hole of the disc as it passes the aperture, light from

the three lamps—each controlled by its appropriate signal from the sending end. When the intensities of the three images are properly adjusted, he therefore sees an image in its true colors, with the general appearance of a small colored motion picture.

TRANSATLANTIC SERVICE EXTENSIONS

TRANSATLANTIC telephone service was extended to Belfast in Northern Ireland, to Dublin in the Irish Free State and to the Isle of Man on August 26th. On August 28th it was extended to Milan, Italy, and a few weeks later it was further extended to Turin and to Genoa, the birthplace of Columbus. On October first it was extended from Prague to include all of Czecho-Slovakia.

The rate for a telephone conversation between New York City and these points in Ireland is $46.50 for the first three minutes and $15.50 for each additional minute. The rate between New York and any of the three Italian cities is $51 for the first three minutes and $17 for each additional minute.

Calls from America to Ireland are routed through New York City to one of the Bell System's radio transmitting stations, across the Atlantic to a receiving station in Great Britain and thence by wire to London. From London telephone wires carry the calls to submarine cables running under the Irish Sea.

Connection with the Irish Free State is established through a cable between Nevin in Carnarvonshire, Wales, and Howth in County Dublin. A cable between Port Mora on the Stranraer Peninsula in Wigtownshire, Scotland and Donaghadee in County Down connects Northern Ireland with the mainland. The Isle of Man is linked by a new cable from Blackpool in Lancashire to Douglas on the island. An extension of the latter cable will ultimately provide new direct circuits between London and Belfast. There are about 47,000 telephones in Ireland.

Calls from America to Italy will be transmitted to London over the same route as other transatlantic calls. From London telephone wires will carry the calls to submarine cables under the English Channel. From the Channel telephone wires will again carry the calls across France and Switzerland. In all the messages will travel over a circuit of approximately 4,400 miles.

Milan, Turin and Genoa have a total of more than 100,000 telephones and a combined population of nearly two million. These extensions put the American telephone user in voice communication with twenty-one foreign countries.

TRANSATLANTIC SERVICE PLACED ON 24-HOUR BASIS

TO meet the requirements of a constantly increasing traffic, transatlantic telephone service was put on a twenty-four hour basis beginning September 10th. The round-the-clock service extends to all points in Europe connected to America by the overseas circuits. For the past year the daily service period has been from 6:30 A.M. to 10 P.M., New York time.

When the service was first inaugurated between New York and London on January 7, 1927, the period of service was from 8:30 o'clock in the morning to 1 P.M., Eastern Standard Time. Later, on April 10 of the same year, this period was extended from 7:30 A.M. to 1 P.M., Eastern Standard Time. Another hour in the morning was added on April 24, and shortly thereafter the time was extended in the afternoon to 5 P.M. and subsequently to 6 P.M.

On March 4, 1928, coincident with the reduction of rates, the period of operation was extended to 8 P.M., Eastern Standard Time, and on June 4, 1928, it was made available up to 9 P.M., Eastern Standard Time. This was further extended to 10 P.M. on September 30, 1928.

Effective September 10, 1929, the service became continuous. The differences in international time, which between California and middle Europe amount to nine hours, hitherto had interfered with the full use of the service, but this has now been corrected by the change in the hours.

BELL SYSTEM OFFICIALS TELEPHONE TO AUSTRALIA

America talked with Australia through regular telephone instruments for the first time on September 25th when officials of the American Telephone and Telegraph Company exchanged greetings with the Australian telephone officials in Sidney. The occasion was an informal demonstration of the practicability of connecting the transatlantic telephone channel operated by the American Telephone and Telegraph Company and British Post Office with the new short wave radio telephone channel operated by the British General Post Office between Great Britain and the Australian Continent. The directive short wave transatlantic radio channel that is now in regular use for European service was used in the demonstration instead of the long wave channel so that the voices of the speakers were carried a total distance of 15,000 miles by the short wave system of transmission interconnecting the wire systems of the United States and Australia.

From the office of President Walter S. Gifford of the American Telephone and Telegraph Company calls passed over wire lines to the company's short wave transmitting center at Lawrenceville, N. J.; thence by radio to the short wave receiving station of the British General Post Office at Baldock near London, England; and thence by wire via London to the British Government's transmitting station at Rugby, England, and again by radio to the receiving sation of Amalgamated Wireless of Australia, near Sidney. The return path

was again to Baldock; thence via Rugby to the Bell System's short wave receiving station at Netcong, N. J.

An interesting aspect of the conversations was that, taking place at four o'clock, September 25, New York time, the clocks in Sidney read six A.M., September 26.

The conversations were between President Gifford of the American Telephone and Telegraph Company, Dr. Frank Jewett, President of the Bell Telephone Laboratories, Vice President Arthur W. Page, American Telephone and Telegraph Company, and T. G. Miller, General Manager Long Lines, American Telephone and Telegraph Company, on the American side; and Mr. A. S. MacDonald of Amalgamated Wireless of Australia.